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Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^3 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIATION DATA AND REPORTS

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Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

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Published under the direction of

Dr. William A. Mills
Acting Deputy Assistant Administrator
for Radiation Programs
Office of Radiation Programs

Address correspondence to the Editor, *Radiation Data and Reports*, Office of Radiation Programs, Parklawn 18B-40, Washington, D.C. 20460.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

Radioactive Waste Discharges to the Environment from Nuclear Power Facilities

Joe E. Logsdon[1]

Data relating to discharges of radioactive liquid and gaseous waste have been compiled for 12 selected operating nuclear power facilities. These data are presented and compared to discharge limits and quantity of electric power produced. In most instances, concentration of radioactivity in waste discharge limits have been maintained at a few percent of the Atomic Energy Commission's licensed discharge limits. Exceptions are mostly associated with either an unusually high percentage of leaky fuel elements or with liquid discharge limits which are artificially low because liquid wastes, in some cases, are not analyzed for radionuclide content.

Comparison of power produced to liquid and gaseous waste discharges showed that boiling water reactors discharge relatively large quantities of gaseous waste and pressurized water reactors discharge relatively high quantities of tritium in liquid waste. No obvious trend is discernible concerning the quantity of radioactive waste discharged as a function of power generation.

Nuclear power plants produce large quantities of radioactive material as byproducts of the operation of the reactor. Most of the radioactive material is contained within the fuel elements and remains there until the fuel is chemically reprocessed at a fuel reprocessing facility. The relatively small portions of radioactive material that escape from the fuel or are produced outside the fuel are contained and processed as radioactive waste at the nuclear power plant. Processing of radioactive waste is geared to decontamination of the waste streams by concentration processes (such as evaporation and demineralization in the case of liquid wastes) with the radioactivity-bearing concentrate shipped offsite for burial at licensed sites. Decontamination is not 100 percent efficient and small amounts of radioactive materials are discharged to the atmosphere and receiving waters. The quantities and types of waste discharged vary from facility to facility depending primarily on design characteristics of the plant and on waste management practices.

[1] Surveillance and Inspection Division, Office of Radiation Programs U.S. Environmental Protection Agency, Washington, D.C. 20406.

Measurements of radioactivity in the environs of nuclear power plants made by State health departments, nuclear power facility operators, and the Environmental Protection Agency (EPA) have, in most cases, revealed little or no increase in environmental radioactivity resulting from plant operations. In those cases where increases were measured, the levels were barely detectable.

This report summarizes the publication, *Radioactive Waste Discharges to the Environment from Nuclear Power Facilities* (*1*) and an addendum to that publication (*2*), excluding the appendices in these reports.

It was determined by routine compliance inspections conducted by the Atomic Energy Commission (AEC) during the first half of 1971, that sampling and analytical methods used at some nuclear power facilities were inappropriate to measure the total activity from all radionuclides in liquid and gaseous effluents. As a result, the AEC required facility operators to resubmit 1970 discharge data that had been included in operating reports. The revised data were published by AEC, Division of Compliance, in a report, *Report on Releases of Radio-*

activity from Power Reactors in Effluents During 1970 (*3*). The revised data showed both decreases and increases in quantities discharged. Although there are no significant safety implications in the AEC revised estimates, they show a need for standardization in methods for determining quantities of radioactive material released. This report corrects the 1970 data that appeared in the October 1971 addendum (*2*) to agree with revised estimates published in the AEC report (*3*).

Most of the data in the tables that follow were taken from nuclear facility operating reports and AEC reports. None of the data sources provided statistical error associated with the data and therefore no such indications are included in this report.

Additional information on radionuclides in radioactive wastes from boiling-water reactors is available from a report on a special study by the Bureau of Radiological Health, around the Dresden Nuclear Power Station (*4*). Similar studies have been performed by the EPA, Office of Radiation Programs, around two pressurized water reactors, Yankee (*5*) and Connecticut Yankee. A report of the latter study will be available during the second half of 1972.

Administrative controls

Discharge of radioactive waste to the environment by nuclear power facilities is regulated by the AEC through an operating license issued to the nuclear facility operator. The license requires the licensee to operate the plant in accordance with written Technical Specifications that have been approved by the AEC which include, among other items, limits for radioactive liquid and gaseous discharges. Discharge limits presented in the Technical Specifications are based on maximum permissible concentrations for air and water listed in Appendix B, Table II, 10CFR20 (*6*). These limits take into account the dilution which occurs in the condenser cooling water discharge canal for liquid effluents and in the atmosphere between the point of release and the boundaries of the exclusion area for gaseous effluents. ("Exclusion area" means that area surrounding the reactor in which the licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area.) Discharge limits may further be reduced by the AEC to compensate for possible reconcentration of radionuclides by environmental media. For example, the gaseous discharge limits applied in the licensing process to iodine-131 releases are reduced by a factor of 700 to compensate for possible reconcentration through the pasture-cow-milk exposure pathway.

Sources of liquid and gaseous waste

Radioactivity at nuclear power facilities is produced primarily as a byproduct of the fission process or from neutron activation of structural material within the pressure vessel and impurities in the primary coolant. A combination of leakage of fission products through the fuel cladding into the primary coolant and activation of materials outside the fuel makes the primary coolant the principal source of liquid and gaseous wastes. However, leakage of primary coolant into other systems and various plant operations cause the sources to be numerous. Typical plant operations which result in liquid or gaseous radioactive waste include:

1. refueling and maintenance,
2. control of primary coolant chemistry,
3. sampling,
4. rejection of noncondensable gases from steam condensers,
5. blowdown of steam generators,
6. expansion water when the plant goes from a cold to a hot operation,
7. decontamination of clothing, components, tools, and surfaces, and
8. regeneration of demineralizer resins.

The activation of impurities in systems other than the primary coolant system has not been a major source of liquid radioactive wastes in light water reactors. However, at the Peach Bottom Nuclear Power Station (a high temperature gas-cooled reactor) the absence of liquid radioactive wastes from the primary coolant system makes the primary shield cooling system the principal source of liquid wastes.

Measurements of concentrations of specific radionuclides present in gaseous and liquid wastes are not generally available from nuclear

power plants. Normally, facility operators report only gross beta-gamma activity and sometimes tritium activity in liquid wastes. Gaseous waste discharges are generally categorized and reported by facility operators as being either halogens and particulates or activation and noble gases. Some facility operating reports include results of specific radionuclide analyses of primary coolant. However, the relative abundance of radionuclides in the primary coolant may be different than the relative abundance in liquid or gaseous waste effluents. Relative abundance of radionuclides in the primary coolant are functions of:

1. cladding leakage,
2. temperature changes which may cause release of particles that have been attached to the surface of the primary system,
3. use and effectiveness of coolant purification,
4. rate of primary system leakage,
5. chemical additives in the primary coolant,
6. type of coolant, and
7. power history.

Relative abundances of radionuclides in the waste effluents are primary functions of:

1. their abundance in the primary coolant,
2. their respective half-lives,
3. design of the radioactive waste treatment system, and
4. waste treatment practices.

Waste treatment capabilities at selected operating nuclear facilities are summarized in table 1.

Most radionuclides can be classified as either fission products or activation products. Tritium, however, is a special case in that it is produced both from fissioning and from neutron activation. It is also special because it is not affected by methods presently used in processing radioactive wastes. Therefore, the tritium released to the primary coolant or produced in the primary coolant is ultimately discharged to the environment in either liquid or gaseous form. Additional information on environmental tritium contamination from nuclear energy sources is provided in reference (*7*).

Operating experience

Most experience on radioactive waste discharge to date has been with pressurized water reactors (PWR) (*8*) and boiling water reactors (BWR) (*9*). Limited operating experience has been gained from a high temperature gas-cooled reactor (HTGR) through the operation of Peach Bottom-1 (*10*). Table 2 provides general information for facilities included in this report.

Liquid discharges

Quantities of gross beta-gamma activity (exclusive of tritium) discharged annually by each facility are shown in table 3. Operating reports for Dresden-1 did not indicate total amount of

Table 1. Waste-processing capability at operating nuclear power facilities

Reactor	Gaseous waste treatment			Liquid waste treatment
	Design holdup or delay time	Particulate treatment	Iodine treatment	
Pressurized water reactors:				
Shippingport	60 days	None	None	Filtration, evaporation, demineralization, gas scrubbing
Yankee	60 days	None	None	Filtration, evaporation, demineralization
Indian Point–1	120 days	Absolute filters	None	Filtration, evaporation, demineralization, gas stripping
San Onofre	30 days	High efficiency filters	None	Filtration, demineralization, gas stripping
Connecticut Yankee	Variable	Fiberglass filter	None	Evaporation, demineralization
Robert E. Ginna	45 days	Filtration	None	Filtration, evaporation, demineralization, gas stripping
Boiling water reactors:				
Dresden–1	20 minutes	Absolute filters	None	Filtration, evaporation, demineralization
Big Rock Point	30 minutes	Absolute filters	None	Filtration, evaporation, demineralization
Humboldt Bay	18 minute design 40 minute design	Absolute filters	None	Filtration, evaporation, demineralization
La Crosse	20 minutes	None	None	Filtration, evaporation, demineralization
Nine Mile Point	30 minutes	Absolute filters	None	Filtration, demineralization
Oyster Creek	30 minutes	Absolute filters	None	Filtration, evaporation, demineralization
High temperature gas-cooled reactor:				
Peach Bottom–1	Variable	Filtration	Charcoal filters	Demineralization

Table 2. General information for facilities included in this report

Facility	AEC docket number	Power level (*11*)		Location	Vent or stack height (feet)	Vent or stack exhaust rate (cubic feet per minute)	Condenser water for dilution flow rate (gallons per minute)	Body of water receiving liquid waste
		MWt	MWe net					
Pressurized water reactors:								
Shippingport	None	505	90	Shippingport, Pa.	[a] 26	9,000	114,000	Ohio River
Yankee	50–29	600	175	Rowe, Mass.	150	15,000	138,000	Deerfield River
Indian Point–1	50–3	615	265	Buchanan, N.Y.	400	280,000	300,000	Hudson River
San Onofre	50–206	1,347	430	San Clemente, Calif.	100	40,000	350,000	Pacific Ocean
Connecticut Yankee	50–213	1,825	573	Haddam Neck, Conn.	175	70,000	372,000	Connecticut River
Robert E. Ginna	50–244	1,300	420	Rochester, N.Y.	150	[b]	334,000	Lake Ontario
Boiling water reactors:								
Dresden–1	50–10	700	200	Morris, Ill.	300	45,000	166,000	Illinois River
Big Rock Point	50–155	240	71	Charlevoix, Mich.	240	30,000	50,000	Lake Michigan
Humboldt Bay	50–133	240	68	Eureka, Calif.	250	12,000	[c] 100,000	Humboldt Bay
La Crosse	115–5	165	50	Genoa, Wis.	350	70,000	[d] 240,000	Mississippi River
Nine Mile Point	50–220	1,538	500	Oswego, N.Y.	350	216,000	600,000	Lake Ontario
Oyster Creek	50–219	1,690	560	Toms River, N.J.	99	[b]	640,000	Atlantic Ocean
High temperature gas-cooled reactor:								
Peach Bottom–1	50–171	115	40	Peach Bottom, Pa.	150	20,000	43,000	Susquehanna River

[a] Gas discharge stack; vapor container exhaust stack 116 feet.
[b] Information not available.
[c] Flow rate for Humboldt Bay Unit 3 is 51,800 gallons per minute. All calculations are based on a flow rate of 100,000 gallons per minute which is the combined rate for Humboldt Bay Units 1, 2, and 3. Units 1 and 2 are fossil fuel plants.
[d] Includes 180,000 gallons per minute from the Genoa #3 fossil station, which is connected to the La Crosse boiling water reactor outfall.

radioactivity discharged, but gave an average contribution to the radioactivity in the condenser cooling water discharge canal. Except as noted in the table, the total annual discharge for Dresden was obtained by multiplying the facility's contribution to the concentration of radioactivity in the condenser cooling discharge canal times the annual flow rate of the canal as calculated from table 2.

The data in table 3 indicate a general increase in quantities of radioactivity discharged in liquid wastes since 1968 for most of the facilities operating in that year. Exceptions include Shippingport, the Indian Point Station, Big Rock Point, and the Humboldt Bay Power Plant Unit 3. Waste treatment practices are major factors in determining the quantity of radioactivity in liquid wastes available for discharge. Therefore, the reasons for reductions or increases in discharge quantities are generally not discernible from a review of the operating reports. However, the Indian Point Station was shut down for maintenance during most of 1970. This could have contributed to a reduction in discharge quantities.

Calculations have been made based on the data in tables 2 and 3 and the liquid discharge limits for each facility to provide comparisons to discharge limits. These comparisons are provided in table 4. These data do not include tritium which is presented later.

With the exception of Shippingport,[2] discharge limits are prescribed by Technical Specifications. All Technical Specifications limit concentrations in liquid effluents to those listed in Appendix B, Table II of 10CFR20. Without analysis of specific radionuclides, the annual average limit is considered to be 10^{-7} μCi/ml. If liquid wastes are analyzed for specific radionuclides, discharge limits can be based on the maximum permissible concentration for the radionuclides present. These limits normally are less restrictive than the limit for unidentified radionuclides. Most nuclear power plants discharge sufficiently small quantities of radioactivity in liquid wastes that dilution factors associated with the condenser cooling canal are sufficient to permit discharge on the basis of unidentified radionuclides. In most cases, there is no requirement for reporting radionuclide analyses of wastes in operating reports and as a result they are not normally reported. There-

[2] Shippingport has been developed and operated under AEC sponsorship. Shippingport radioactivity discharge limits are equal to or less than radiation protection standards set forth in Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524 and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Table 3. Total annual liquid waste discharged [a]

Facility	Gross beta-gamma exclusive of tritium (curies)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport[c]	0.083	0.21	0.129	0.09	0.19	0.53	0.14	0.06	0.07	0.08	0.208	0.07
Yankee			.008	.008	.003	.002	.029	.036	.055	.008	.019	.034
Indian Point-1				.130	.164	13.0	26.3	[d]43.7	[e]28.0	[f]34.6	[f]28.0	7.8
San Onofre									.32	1.6	8.0	7.6
Connecticut Yankee									.216	3.9	12.8	6.7
Robert E. Ginna											.017	10
Boiling water reactors:												
Dresden-1		.770	2.095	2.61	2.78	3.82	8.7	11.5	[e]4.3	6.1	[f]9.5	8.2
Big Rock Point[g]				.2	.63	6.22	2.80	6.12	10.1	7.9	11.81	4.7
Humboldt Bay					.397	.664	1.89	2.34	3.13	3.2	1.5	2.4
La Crosse											[f]8.7	6.4
Nine Mile Point											[f].9	28
Oyster Creek											[f].48	18.5
High temperature gas-cooled reactor:												
Peach Bottom-1									.0017	.0004	.000185	.006

[a] Based on operators' reports except as noted.
[b] Data taken from reference (*5*).
[c] Data taken from *Radiological Health Data and Reports* (*12*).
[d] Data taken from correspondence dated 2/6/70 from Mr. Donald J. McCormick, Consolidated Edison Co. of New York, Inc., to Mr. J. E. Logsdon, Division of Environmental Radiation, USPHS.
[e] Data taken from reference (*13*).
[f] Data taken from reference (*14*).
[g] Data taken from correspondence dated 1/29/70 from Mr. Donald J. McCormick, Consolidated Edison Company of New York, Inc., to Mr. J. E. Logsdon, Division of Environmental Radiation, USPHS.

Table 4. Annual average liquid radioactive-waste discharge concentrations expressed as percent of limit [a]

Facility	Beta gamma radioactivity exclusive of tritium (Percent of discharge limit)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport	0.37	0.93	0.57	0.40	0.84	2.34	0.62	0.27	0.31	0.35	0.91	0.31
Yankee			.03	.03	.01	.007	.1	.13	[c].02	.03	.07	.14
Indian Point-1				.22	.26	22.0	43.0	70.1	[d]1.55	[e]1.65	[f]1.5	.28
San Onofre									.46	3.1	12.8	12
Connecticut Yankee									[d].01	5.35	[g]1.4	2.8
Robert E. Ginna											[h].11	5.0
Boiling water reactors:												
Dresden-1		2.33	6.34	7.9	8.42	11.6	26.4	34.8	13.0	18.5	22.5	25
Big Rock Point				4.46	14.2	54.4	42.4	62.5	[i]50.4	[h]82.3	[m]5.5	3.1
Humboldt Bay					2.77	3.37	9.52	12.15	16.89	19.7	8.7	15
La Crosse											.11	.067
Nine Mile Point												21
Oyster Creek												71
High temperature gas-cooled reactor:												
Peach Bottom-1									.02	.005	.002	.15

[a] Percent of limit calculations were based on the following: (1) 10CFR20 limit for unidentified radionuclides in water of 10^{-7} μCi/ml except as noted, (2) average flow rates in the discharge canals equal to those given in table 2.
[b] Data taken from reference (*5*).
[c] Concentration limit 10×10^{-7} μCi/ml, based on radionuclide analysis.
[d] Concentration limit 30×10^{-7} μCi/ml, based on radionuclide analysis.
[e] Concentration limit 35×10^{-7} μCi/ml, based on radionuclide analysis.
[f] Concentration limit 27×10^{-7} μCi/ml, based on radionuclide analysis.
[g] Concentration limit 12×10^{-7} μCi/ml, based on radionuclide analysis.
[h] Concentration limit 3×10^{-7} μCi/ml, based on radionuclide analysis.
[i] Concentration limit 2×10^{-7} μCi/ml, based on radionuclide analysis.
[k] Concentration limit 1.5×10^{-7} μCi/ml, based on radionuclide analysis.
[m] Concentration limit 22×10^{-7} μCi/ml, based on radionuclide analysis.

Table 5. Comparison of radioactive-waste discharges to electrical power generation

Facility and reactor	Period covered	Total waste discharges during period			Total gross electrical generation (MWe-h)	μCi discharges/MWe-h gross		
		Liquid		Gaseous		Liquid		Gaseous
		Gross beta-gamma[a] (curies)	Tritium (curies)	Gross beta-gamma (curies)		Gross beta-gamma exclusive of tritium	Tritium	Gross beta-gamma
Pressurized water reactors:								
Shippingport	1959–68	1.6	281	0.58	3.5×10^{6}	0.46	80	0.17
	1968	.08	35.2	.001	4.1×10^{5}	.20	86	.002
	1969	.21	20	7.5×10^{-5}	3.4×10^{5}	.61	59	2.2×10^{-4}
	1970	.071	1.71	1.9×10^{-5}	3.9×10^{5}	.18	4.4	5×10^{-4}
Yankee	1961–68	.15	[c]6,080	37	8.9×10^{6}	.02	[c]1,220	4.16
	1968	.008	1,170	.68	1.2×10^{6}	.007	950	.57
	1969	.019	1,225	4.14	1.2×10^{6}	.016	1,020	3.45
	1970[b]	.034	1,500	17	1.3×10^{6}	.009	385	4.4
Indian Point–1	1964–68	112	[d]1,080	166	6.2×10^{6}	17.1	[d]319	26.77
	1968	34.6	787	59.6	1.6×10^{6}	21.6	492	37.2
	1969	28	1,100	600	1.8×10^{6}	15.5	611	333
	1970[b]	7.8	410	1.8×10^{3}	[e]			
San Onofre	1967–68	1.92		8.8	1.7×10^{6}	1.1		5.18
	1968	1.6	2,350	4.83	1.4×10^{6}	1.1	1,680	3.45
	1969	8.0	3,531	256	2.8×10^{6}	2.86	1,260	91.5
	1970[b]	7.6	4,800	4.2×10^{3}	3.2×10^{6}	2.4	1,500	,310
Connecticut Yankee	1967–68	4.1	1,960	3.75	3.7×10^{6}	1.1	530	1.01
	1968	3.9	1,740	3.74	3.2×10^{6}	1.3	544	1.17
	1969	12.8	5,100	190	3.8×10^{6}	3.4	1,342	50
	1970[b]	6.7	7,400	700	3.7×10^{6}	1.8	2,000	189
Robert E. Ginna	1969	.017	1.26	0	1.5×10^{5}	.11	8.4	0
	1970[b]	10	110	1×10^{4}	2.3×10^{6}	4.3	47.8	4.35×10^{3}
Boiling water reactors:								
Dresden–1	1961–68	41.9		2.8×10^{6}	7.6×10^{6}	5.5		3.68×10^{4}
	1968	6.1	2.9	2.4×10^{5}	9.7×10^{5}	6.3	3	2.47×10^{5}
	1969	9.5	6	8.6×10^{5}	8.7×10^{5}	11	6.9	9.9×10^{5}
	1970[b]	8.2	5	9.1×10^{5}	1.4×10^{6}	5.86	3.57	6.5×10^{5}
Big Rock Point	1962–68	33.1		1.33×10^{6}	1.7×10^{6}	19.5		7.82×10^{4}
	1968	7.5	[f]34	2.32×10^{5}	4.5×10^{5}	17.6	76	5.16×10^{4}
	1969	11.8	28	2.0×10^{5}	4.2×10^{5}	28.1	67	4.8×10^{4}
	1970[b]	4.7	54	2.8×10^{5}	4.0×10^{5}	11.8	135	7.0×10^{5}
Humboldt Bay[g]	1963–68	11.4	<248	2.23×10^{6}	1.8×10^{6}	6.3	<138	1.24×10^{6}
	1968	3.20	<6.6	8.53×10^{5}	4.7×10^{5}	6.9	15	1.83×10^{6}
	1969	1.5	<5	4.9×10^{5}	3.9×10^{5}	3.85	<13	1.0×10^{6}
	1970[b]	2.4	<7	5.4×10^{5}	4.3×10^{5}	5.58	<16	1.3×10^{6}
La Crosse	1969	8.7		480	7.7×10^{4}	.01		6.3×10^{2}
	1970[b]	6.4	20	950	1.3×10^{5}	49.2	154	7.3×10^{3}
Nine Mile Point	1969	.897		55	7.1×10^{4}	.001		7.8×10^{2}
	1970[b]	28	20	9.5×10^{3}	1.9×10^{6}	14.7	10.5	5.0×10^{3}
Oyster Creek	1969	.481	5.066	7.0×10^{3}	3.5×10^{5}	1.37	14.5	2.0×10^{4}
	1970[b]	18.5	22	1.1×10^{5}	3.5×10^{6}	5.1	6.1	3.1×10^{4}
High temperature gas-cooled reactor:								
Peach Bottom–1	1967–68	.002		117	3.1×10^{5}	.006		377
	1968	.0004		109	1.5×10^{5}	.003		727
	1969	.0002	40	71.5	1.5×10^{5}	.001	267	476
	1970[b]	.006	<50	5.7	[e]			

[a] Exclusive of tritium.
[b] Data taken from reference (*3*).
[c] Based on data for 1965–68 wherein electrical generation was 4.98×10^{6} MWe-h.
[d] Based on data for 1967–68 wherein electrical generation was 3.39×10^{6} MWe-h.
[e] Down for repairs.
[f] Based on an upper limit calculation wherein all liquid waste released during 1968 was assumed to contain as much tritium as was in primary system water.
[g] Data from Pacific Gas and Electric records.

fore, the limit for unidentified radionuclides has been used as the basis for comparison in table 4 except as noted.

The percentages expressed in table 4, in most cases, do not represent a true figure. This is because the discharge limit is a function of the concentration of individual radionuclides present in the waste, and the limit becomes more restrictive with less analysis for specific radionuclides. Therefore, the percentages expressed in table 4 generally can be considered as representing less-than quantities.

The data in table 5 show the ratio of gross beta-gamma radioactivity or tritium discharged to power produced for each facility. Comparison of 1969 and 1970 data on quantities of gross beta-gamma radioactivity in liquid waste discharged per unit of power generation shows a decrease for most PWR's and an increase for most BWR's. However, the facilities that show

increased ratios are, with the exception of Humboldt Bay, new facilities.

Gaseous waste discharges per unit of power produced showed a factor of 40 decrease at Shippingport from 1968 to 1970, and a factor of nine increase from 1968 to 1969 at Indian Point. The Indian Point facility was shut down during most of 1970 for maintenance, as mentioned. Some of these repairs (e.g., steam generator tube repairs) should result in reduced quantities of gaseous waste available for discharge in the future. Gaseous discharges per unit of power produced from San Onofre and Connecticut Yankee increased by factors of 370 and 175, respectively, from 1968 to 1970. Reasons for these increases were not explained in the operating reports. Gaseous discharges per unit of power produced at other facilities showed no particular trends.

Figure 1 compares annual discharges of radioactivity in liquid wastes to power generation for facilities included in this report. This figure indicates that both electrical generation and liquid waste discharges are increasing with time, but that radioactivity in liquid waste discharges is not increasing as rapidly as electrical generation.

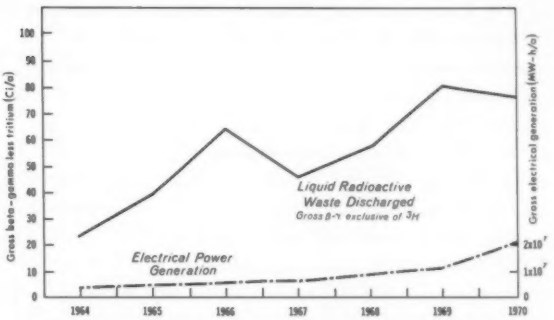

Figure 1. Comparison of annual liquid radioactive waste discharged from all facilities to annual electrical power generation

The ratio of curies of tritium discharged in liquid waste to electrical power produced shows that PWR's, using soluable boron in the primary coolant, discharge relatively higher quantities than BWR's and HTGR's. Higher tritium concentrations in PWR's are due in part to neutron reactions with boron which is added in the form of boric acid to the primary coolant. Since the boron is in solution with the primary coolant, there is no cladding barrier to retain the tritium so produced. This is not the case with a BWR where the boron is used

Table 6. Total annual liquid tritium discharges [a]

Facility	Liquid tritium discharge (curies)												
	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:													
Shippingport[c]	50.0	64.0	99.0	13.2	1.33	2.17	1.39	3.04	27.3	34.8	35.2	20.0	1.71
Yankee[d]				—	—	—	—	1,300	1,920	1,690	1,170	1,230	1,500
Indian Point-1					—	—	—	—	[e]125	[e]297	[e]787	[f]1,100	410
San Onofre										—	2,353	3,530	4,800
Connecticut Yankee										221	1,740	5,100	7,400
Robert E. Ginna												1.26	110
Boiling water reactors:													
Dresden-1			—	—	—	—	—	—	—	—	[g]2.9	[f]6.0	5
Big Rock Point					—	—	—	—	—	—	[g]34	[f]28	54
Humboldt Bay						[h]214	[h]100	[h]54	[h]60	[h]166	[h]6.6	[f]<5	<7
La Crosse													20
Nine Mile Point													20
Oyster Creek												5.066	22
High temperature gas-cooled reactor:													
Peach Bottom-1										—	[i]	[f]40	<50

[a] Data taken from facility operating reports except as noted.
[b] Data taken from reference (*3*).
[c] Data for years 1958 through 1960 taken from *Shippingpor Operations from Power Operations after First Refueling to Second Refueling (May 1960 to August 16, 1961)* DLCS-36402; data for years 1961 through 1969 taken from *Radiological Health Data and Reports* (*12*).
[d] Data taken from *Yankee Nuclear Power Station Operation Report(s)*; tritium analysis was not included in the operating reports prior to 1965.
[e] Data taken from reference (*13*).
[f] Data taken from reference (*14*).
[g] Based on an upper limit calculation wherein all liquid waste released during 1968 was assumed to contain as much tritium as was in primary-system water.
[h] Data taken from Pacific Gas and Electric records.
[i] Negligible.
— data not available.

Table 7. Tritium discharges in liquid wastes compared to AEC limits [a]

	Average discharge[b] concentration (μCi/ml)			Percent of limit		
	1968	1969	1970[c]	1968	1969	1970[c]
Pressurized water reactors:						
Shippingport	1.6×10^{-7}	8.8×10^{-8}	7.5×10^{-9}	0.0053	0.003	0.0002
Yankee	4.5×10^{-6}	4.4×10^{-6}	5.5×10^{-6}	.15	.15	.18
Indian Point-1	1.6×10^{-6}	1.8×10^{-6}	6.9×10^{-7}	.045	.06	.02
San Onofre	5.0×10^{-6}	5×10^{-6}	6.9×10^{-6}	.17	.17	.23
Connecticut Yankee	2.4×10^{-6}	6.8×10^{-6}	1.0×10^{-5}	.08	.23	.33
Robert E. Ginna		1.9×10^{-9}	1.7×10^{-7}		.00006	.005
Boiling water reactors:						
Dresden-1	9×10^{-9}	1.8×10^{-6}	1.5×10^{-6}	.0003	.0006	.0005
Big Rock Point	3.6×10^{-7}	2.8×10^{-7}	5.4×10^{-7}	.012	.01	.02
Humboldt Bay	$<4.0 \times 10^{-8}$	$<2.5 \times 10^{-8}$	$<3.5 \times 10^{-8}$	<.0014	<.001	<.001
La Crosse			4.2×10^{-8}			.001
Nine Mile Point			1.7×10^{-9}			.0006
Oyster Creek		4.3×10^{-8}	1.7×10^{-8}		.001	.0006
Gas cooled reactors:						
Peach Bottom-1	Negligible	4.6×10^{-7}	$<5.8 \times 10^{-7}$	Negligible	.015	<.02

[a] Based on 10CFR20 limit for unrestricted areas of 3×10^{-3} μCi/cc and dilution in the condenser cooling water discharge canal.
[b] Calculation based on annual quantity of tritium discharged and the condenser cooling water flow rate.
[c] Data taken from reference (3)

in the form of cladded plates or curtains. Other sources of tritium which are common to both PWR's and BWR's include fission product tritium and reactions of neutrons with lithium-7 nitrogen, helium-3, poison material used in control rods or plates, and reactions with structural material.

Discharges of tritium in liquid wastes are generally reported separately from gross beta-gamma discharges primarily because of tritium's high relative abundance in liquid wastes and relatively high discharge concentration limit as compared to the concentration limit for unidentified radionuclides. Data in table 6 indicate that the quantity of tritium in liquid waste is high relative to the quantity of other radionuclides. However, the relative hazard per curie of tritium is low. The data in table 6 are expanded in table 7 to show derived average discharge concentrations and percent of the discharge limit for 1968. Comparing the data in tables 4 and 7, it is evident that concentrations of gross beta-gamma activity (exclusive of tritium) in liquid discharges more nearly approach the limit than do concentrations of tritium. This is significant because current methods for treatment of liquid wastes are ineffective in reducing quantities of tritium discharged.

Gaseous wastes

Gaseous wastes may include particulates, volatiles (such as iodine), or gases. The gases constitute the major portion of discharged radioactivity via the stack and are generally referred to as activation and noble gases.

Technical Specifications limit average discharge rates for radioactive gaseous wastes such that the average annual concentrations at the plant's exclusion boundary will not exceed those listed in Appendix B, Table II of 10CFR20. Additional limits (usually a factor of ten higher than limits for average release rates) are established for maximum release rates. Limits for gaseous release rates are a function of the atmospheric dilution available between the point of release and the exclusion boundary. Since atmospheric dilution factors are affected by stack height, distance from stack to exclusion boundary, topography and local meteorology, gaseous discharge limits vary widely from facility to facility. Limits for gaseous releases are usually expressed in μCi/s with limits for iodines and particulates being relatively more restrictive than the limits for activation and noble gases. The reason for the more restrictive limits for iodines and particulates is their potential for reconcentration through environmental media. For example, the discharge limit for iodine-131 is generally set at a factor of 700 below the rate that would produce the 10CFR20 concentration limit of 1×10^{-10} μCi/ml at the exclusion boundary. This is to compensate for possible

reconcentration through the pasture-cow-milk chain. The isotopic mixtures of noble gas discharges are such that the maximum permissible concentration in the environment as calculated from values listed in 10CFR20 range from 3×10^{-8} μCi/ml with decay of less than 2 hours to 3×10^{-7} μCi/ml at ages of 3 days and longer (*15*). The increase in concentration limits with increased decay time is due to the decay of the short-lived radionuclides which have relatively lower concentration limits.

Table 8 provides an annual summary of discharges of activation and noble gases. With the exception of Humboldt Bay, the facilities included in this report do not include separate discharge rates of halogens and particulates in their operating reports. However, these data have been reported by the AEC in reference (*13*) for 1967 through 1970 and are reproduced in table 9 along with the percent of discharge limit for each facility.

Table 10 provides a summary of annual average discharge rates for activation and noble gases expressed as percent of discharge limits. Unlike other facilities, the discharge limit for Shippingport does not take into consideration atmospheric dilution between the point of discharge and the exclusion boundary. The discharge limit for Shippingport is 3×10^{-7} μCi/ml in the stack. The derivation of the discharge limit (1.26 μCi/s), used in table 10 for calculating percent of limit, is based on a stack discharge rate of 9,000 cubic feet per minute.

Review of the annual discharge rate for each of the facilities listed in table 8 reveals that boiling water reactors discharge very much larger quantities of activation and noble gases than pressurized water reactors. This trend is further verified in table 5 where the ratio of gaseous waste discharged to electrical power produced is presented. The greater quantities of radioactive gases discharged from BWR's are a result of the shorter holdup for decay prior to discharge to the environment. Gases in the primary coolant system of a BWR are carried over with the steam to the condenser air ejectors where they are immediately ejected as noncondensables and discharged to the environment with a holdup time of 20–30 minutes. The radioactive gases generated in a PWR are retained for longer periods in the primary coolant system. Those that are released from the coolant system are stored in tanks for further decay prior to discharge and therefore PWR's discharge less short-lived gaseous wastes to the atmosphere. As a result, population exposure to external radiation from gaseous releases will be higher in the immediate vicinity of a BWR than in the immediate vicinity of a PWR. However, since the increased quantities discharged from a BWR are made up of short-lived radionuclides, the contribution by BWR's to general population exposures should not be greater than for other types of reactors.

Figures 2 and 3 provide plots of electrical generation and gaseous waste discharges as a function of time. The graphs have been separated into BWR's and PWR's. Since gaseous waste discharges at Indian Point-1 have been much higher than at other PWR's, its data were not included. These figures show relationships for each year, but there is not enough history to establish definite trends. Several facilities have been involved in research programs utilizing the reactor to test different fuels and cladding, in some cases resulting in significant releases of fission products from the fuel elements to the primary coolant. Humboldt Bay has experienced a high percentage of leaking fuel cladding resulting in relatively large amounts of fission products being released to the primary coolant. Such releases affect the shapes of the discharge curves in figures 2 and

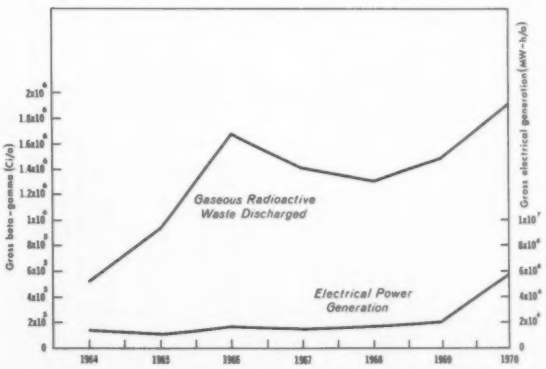

Figure 2. Comparison of annual gaseous radioactive waste discharged to annual electrical power generation for all BWR facilities in table 5

Table 8. Total annual gaseous waste discharged [a]

Facility	Noble and activation gases (curies)											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[b]
Pressurized water reactors:												
Shippingport[c]	0.014	0.029	0.103	0.012	0.351	0.0024	0.032	0.030	0.002	0.001	0.000075	0.000019
Yankee			.00096	21.7	7.4	.95	1.7	2.4	2.3	.68	4.14	17
Indian Point-1				—	.0072	13.2	33.1	36.4	23.4	59.7	[d]600	1,800
San Onofre									4.02	4.83	256	4,200
Connecticut Yankee									.021	3.74	[d]190	700
Robert E. Ginna											0	10,000
Boiling water reactors:												
Dresden-1[e]			34,800	284,000	71,600	521,000	610,000	736,000	[f]260,000	240,000	862,300	910,000
Big Rock Point[g]				25.6	803	783	132,000	705,000	264,000	232,000	200,000	280,000
Humboldt Bay[h]					716	5,975	197,000	282,000	896,000	853,000	492,000	540,000
La Crosse											480	950
Nine Mile Point											55	9,500
Oyster Creek											7,000	110,000
High temperature gas-cooled reactor:												
Peach Bottom-1								.00126	7.76	109	71.5	5.7

[a] Based on operators' reports except as noted.
[b] Data taken from reference (*3*).
[c] Data taken from *Radiological Health Data and Reports* (*12*). Data corrected from 1963 and 1964 taken from correspondence dated 3/10/70 from the Naval Reactors Branch, U.S. Atomic Energy Commission, to Mr. C. L. Weaver, Division of Environmental Radiation, Bureau of Radiological Health.
[d] Data taken from reference (*14*).
[e] Data from 1961 and 1962 based on maximum rate of noble fission gas activity discharged; data from 1963–1968 based on average activity discharge rate for the year while plant was operating.
[f] Data taken from reference (*13*).
[g] Data taken from correspondence dated 3/10/70 from the Naval Reactors Branch, U.S. Atomic Energy Commission, to Mr. C. L. Weaver, Division of Environmental Radiation, Bureau of Radiological Health.
[h] Data taken from Pacific Gas and Electric records.
—, plant was operational but discharge data were not available.

Table 9. Releases of halogens and particulates from power reactors in gaseous effluents

Facility	Permissible[a] (curies)	1967		1968		1969		1970[b]	
		Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release	Quantity released (curies)	Percent of permissible release
Pressurized water reactors:									
Yankee	0.03	Negligible	<1	Negligible	<1	<0.0001	0.01	[c]	
Indian Point	7.6	Negligible	<1	Negligible	<1	.025	.33	.075	1
San Onofre	.8	Negligible	<1	Negligible	<1	<.0001	<.001	<.0001	<.001
Connecticut Yankee	.27	0.001	.5	Negligible	<1	.001	.37	.0015	.7
Robert E. Ginna	1.7					<.0001	<.001	.05	3
Boiling water reactors:									
Dresden–1	85.0	.039	.04	0.15	.15	.30	.35	3.3	4.3
Big Rock Point	38.0	.25	.66	.09	.24	.2	.53	.13	.35
Humboldt Bay	5.6	.64	11	.45	8	.65	12.0	.35	6.2
La Crosse	1.6					<.063	<4.0	<.063	<4
Nine Mile Point	63.0					<.001	<.001	<.06	<.1
Oyster Creek	126.0					.003	.002	.32	.25
High temperature gas cooled reactors:									
Peach Bottom–1	.12	Negligible	<1	Negligible	<1	<.0006	<.5	<.0006	<.6

[a] Where the Technical Specifications do not state an annual limit for the iodines and particulates, an MPC value of 1×10^{-10} μCi/cc was used. This MPC is based on the most restrictive isotope normally found—iodine-131. The annual limit was reduced by a factor of 700 to account for reconcentration.
[b] Data taken from reference (*3*).
[c] Not measured.

Table 10. Annual gaseous radioactive waste discharges

Facility	Noble and activation gases (percent of limit)[a]											
	1959	1960	1961	1962	1963	1964	1965	1966	1967[b]	1968[b]	1969[c]	1970[d]
Pressurized water reactors:												
Shippingport	0.035	0.073	0.26	0.03	0.87	0.006	0.08	0.075	0.005	0.0025	<0.001	<0.001
Yankee			.000014	.32	.11	.014	.025	.035	.036	.008	.063	.26
Indian Point–1					4.5×10^{-7}	.00083	.0020	.0022	.0015	.0037	.01	.03
San Onofre									.0024	.0003	.014	.75
Connecticut Yankee									.00003	.0039	1.0	.24
Robert E. Ginna											0	2.8
Boiling water reactors:												
Dresden–1			.158	1.29	.32	2.37	2.77	3.34	.87	1.09	3.91	5.2
Big Rock Point						.0025	.43	2.27	.85	.74	.65	.88
Humboldt Bay					.045	.38	12.5	17.8	56.7	54.0	31.2	34
La Crosse											.1	.3
Nine Mile Point											<.001	.037
Oyster Creek											.075	1.2
High temperature gas-cooled reactor:												
Peach Bottom–1								6.67×10^{-7}	.04	.087	.38	.003

[a] Percent of limit calculations were based on the following: (1) values as given in table 2 for stack flow rates and table 8 for annual quantities discharged, (2) discharge limits presented in references (*1*) and (*2*) except as noted. In cases where the discharge limit is expressed as a factor times MPC and no MPC is given, then 3×10^{-7} μCi/cc is used.
[b] Limits for 1967 and 1968 from reference (*13*) except for Shippingport. Shippingport limits from reference (*16*) through 1969.
[c] Limits for 1969 based on reference (*14*).
[d] Data taken from reference (*3*).

3 and therefore reduce their significance for establishing trends.

Table 11 has been added to provide an indication of the radionuclides present in liquid and gaseous discharges. Most facilities do not routinely report discharges by individual radionuclide. Review of data in table 11 also shows that the facilities which do report radionuclide data have no consistent format. These situations should be corrected upon promulgation of guides currently proposed by AEC.

Table 11. Radionuclides reported in waste discharges, 1970 [a]

Radionuclides	Humboldt Bay (BWR) (curies)	Connecticut Yankee (PWR) (curies)	Big Rock Point (BWR)	Nine Mile Point (BWR)	La Crosse (BWR)
Gaseous:					
Xenon-133	[b]6,420	603		160 μCi/s	
Xenon-133m	[b]535				
Xenon-135	[b]64,700	[c]84.6		165 μCi/s	
Xenon-135m	82,900				
Xenon-137	4,280				
Xenon-138	217,000			75 μCi/s	
Krypton-83m	13,400				
Krypton-85		[c]9.76			
Krypton-85m	[b]16,600			38 μCi/s	
Krypton-87	[b]73,300			130 μCi/s	
Krypton-88	[b]55,100			110 μCi/s	
Krypton-89	535				
Nitrogen-13				<10 μCi/s	[d]
Argon-41		[c]2.7			
Liquids:					
Chromium-51				60.0 percent	
Manganese-54	.24			5.9 percent	
Cobalt-58		3.94		15.2 percent	[d]
Cobalt-60	.84	.013		9.5 percent	[d]
Zinc-65	.12		42% of total		
Iron-59				9.0 percent	
Iodine-131	.09	.25	[e]	.4 percent	
Cesium-137	.84	.10	[e]		
Cesium-134	.24		[e]		
Strontium-89	[f].01				
Strontium-90	[f].01				

[a] Includes only facilities which reported data on specific radionuclides other than tritium.
[b] These six nuclides are directly measured, the other gaseous nuclides are calculated.
[c] Expressed as xenon-133 equivalent.
[d] Reported as being present but without specific quantities.
[e] Activity was 42 percent zinc-65. The remaining portion was mainly cesium-134, cesium-137, and iodine-131.
[f] Reported by the facility as a conservative estimate.

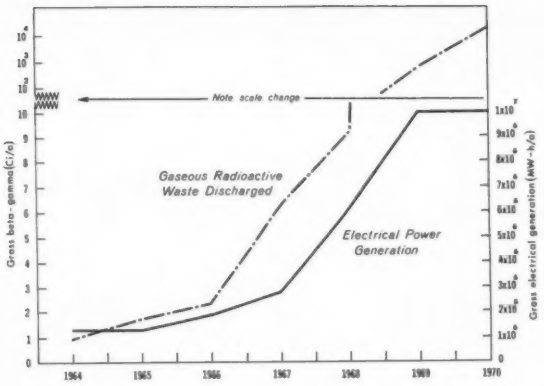

Figure 3. Comparison of annual gaseous radioactive waste discharged to electrical power generation for all PWR facilities except Indian Point Station, Unit 1

of the early reactors did not include the "700" factor to account for possible reconcentration through environmental media.

3. A number of comparisons has been made of power produced versus liquid or gaseous waste discharges. The most predominant trends shown in these comparisons are that boiling water reactors discharge relatively large quantities of gaseous waste and pressurized water reactors discharge relatively high quantities of tritium in liquid wastes. No obvious trend is discernible concerning quantities of waste discharged as a function of power generation. This is to be expected since fuel cladding integrity and waste treatment practices are major factors in determining the quantity of waste available for discharge.

Summary

Data pertaining to discharges of radioactive liquid and gaseous wastes from 12 selected operating nuclear power facilities have been presented and discussed. The following summary is based on these data:

1. Experience to date with nuclear power plants has shown that careful waste management practices, engineered safeguards, and proper operating procedures generally result in radioactivity levels in waste effluents of a few percent or less of the AEC's licensed discharge limits. Exceptions are mostly associated with either an unusually high percentage of leaky fuel elements or with liquid discharge limits which are artificially restrictive as a result of not analyzing liquid wastes for radionuclide content.

2. Technical Specifications for all facilities limit liquid discharges such that average annual concentrations of radioactivity in the condenser cooling discharge canal will be less than values listed in Appendix B, Table II, 10CFR20. The limits for gaseous discharges vary from facility to facility, depending on available dilution factors in the atmosphere. They have varied in the manner in which they are expressed; however, the AEC is in the process of developing uniform reporting requirements. They also have varied in that the limits for halogens and particulates for some

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, November 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk (calcium and potassium) have been used as a means for assessing the biological behav-

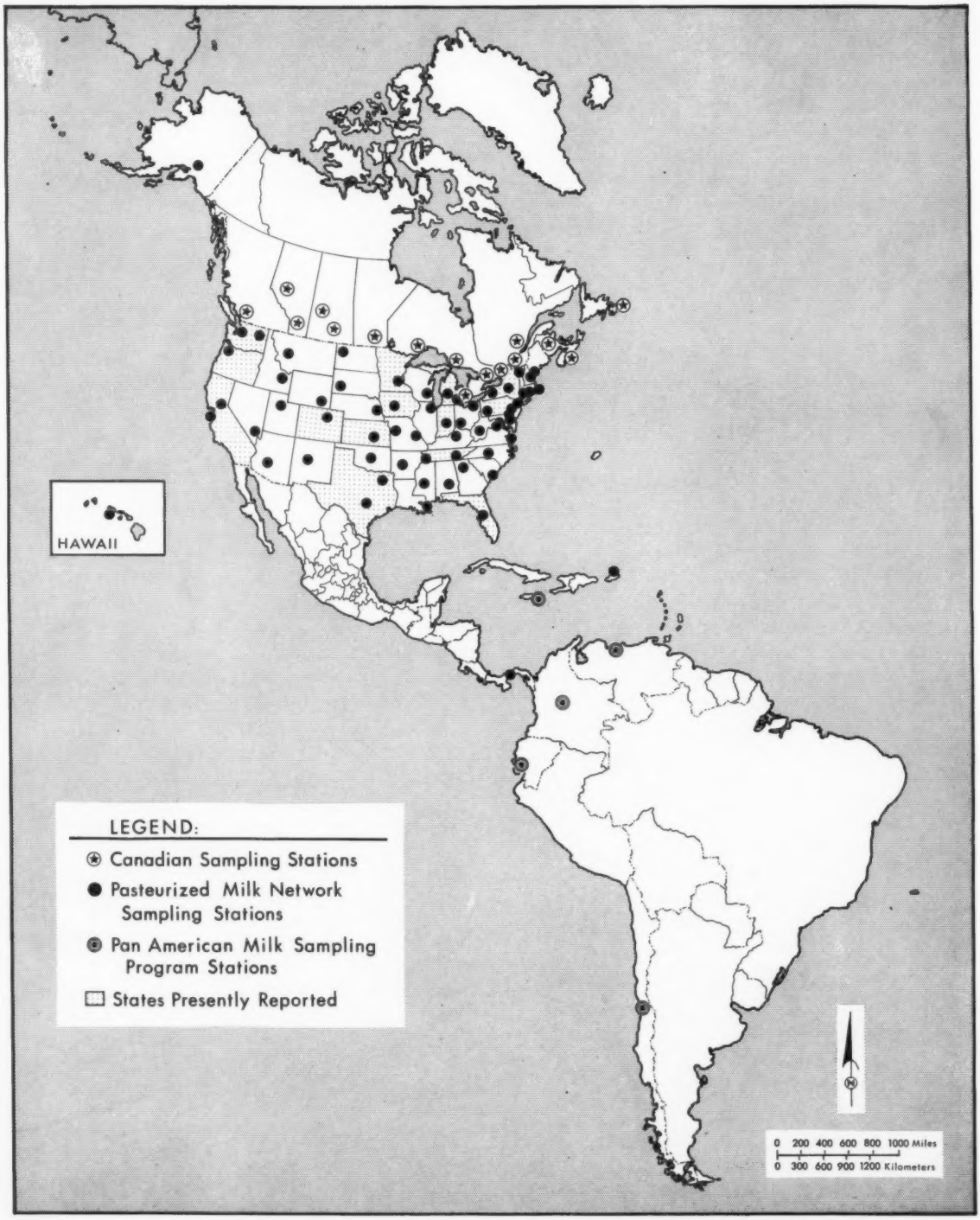

Figure 1. Milk sampling networks in the Western Hemisphere

ior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the experiment.

The accuracy results of this experiment for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of all radionuclides from those of previous studies. Some improvement is still needed on the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

Table 1. Distribution of mean results in milk quality control experiment

Isotope and known concentration $\pm 2\sigma$	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Iodine-131 (69 ±6 pCi/liter)	13 (100%)	0	0	13
Cesium-137 (52 ±6 pCi/liter)	12 (92%)	1 (8%)	0	13
Strontium-89 (31 ±6 pCi/liter)	9 (90%)	1 (10%)	0	10
Strontium-90 (41.6 ±2.4 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not

only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations

Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period December 1970 through November 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	6	11	11
Alaska:	Palmer[c]	P	3	4	22	12
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	10	12	15	13
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	3	0	0
	Del Norte	P	7	14	0	10
	Fresno	P	0	2	0	3
	Humboldt	P	3	4	0	5
	Los Angeles	P	0	2	0	2
	Mendocino	P	2	6	0	7
	Sacramento	P	2	3	0	3
	San Diego	P	0	1	0	3
	Santa Clara	P	0	1	0	4
	Shasta	P	3	3	11	5
	Sonoma	P	0	3	0	5
Colo:	Denver[c]	P	NA	5	0	7
	East	R	[d]		NS	<0
	Northeast	R	[d]		<0	<1
	Northwest	R	[d]		NS	<0
	South Central	R	[d]		<0	<0
	Southeast	R	[d]		NS	
	Southwest	R	[d]		<0	<2
	West	R	[d]		NS	<0
Conn:	Hartford[c]	P	NA	7	0	9
	Central	P	7	7	13	14
Del:	Wilmington[c]	P	NA	8	0	5
D.C:	Washington[c]	P	NA	8	11	9
Fla:	Tampa[c]	P	7	5	41	44
	Central	R	5	6	34	42
	North	R	7	10	14	23
	Northeast	R	6	7	70	35
	Southeast	R	9	7	44	54
	Tampa Bay area	R	6	6	37	43
	West	R	19	11	18	18
Ga:	Atlanta[c]	P	NA	10	17	15
Hawaii:	Honolulu[c]	P	5	3	0	2
Idaho:	Idaho Falls[c]	P	5	5	0	4
Ill:	Chicago[c]	P	5	6	0	9
Ind:	Indianapolis[c]	P	NA	7	0	5
	Central	P	5	8	10	12
	Northeast	P	4	8	5	14
	Northwest	P	8	9	15	14
	Southeast	P	7	9	10	14
	Southwest	P	8	10	20	14
Iowa:	Des Moines[c]	P	NA	5	14	3
	Iowa City	P	4	7	14	14
	Des Moines	P	5	7	11	12
	Little Cedar	P	NS		NS	
	Spencer	P	8	5	0	10
Kans:	Wichita[c]	P	NA	7	11	2
	Coffeyville	P	7	9	0	15
	Dodge City	P	4	6	12	7
	Falls City, Nebr	R	8	4	0	12
	Hays	P	3	10	10	9
	Kansas City	P	4	9	19	15
	Topeka	P	6	9	0	11
	Wichita	P	8	10	17	12
Ky:	Louisville[c]	P	NA	9	0	4
La:	New Orleans[c]	P	15	14	13	20
Maine:	Portland[c]	P	NA	9	0	19
Md:	Baltimore[c]	P	NA	8	0	6
Mass:	Boston[c]	P	7	8	0	13
Mich:	Detroit[c]	P	NA	7	0	11
	Grand Rapids[c]	P	NA	8	0	10
	Bay City	P	7 (3)	6	10 (3)	16
	Charlevoix	P	10 (4)	10	13 (5)	16
	Detroit	P	8	7	0	8
	Grand Rapids	P	4	6	13	11
	Lansing	P	8 (2)	8	12 (2)	16
	Marquette	P	7 (2)	10	21 (2)	23
	Monroe	P	3	5	0 (2)	4
	South Haven	P	6 (3)	6	7 (4)	9
Minn:	Minneapolis[c]	P	NA	8	15	13
	Bemidji	P	8	9	13	19
	Duluth	P	15	17	25	29
	Fergus Falls	P	9	7	13	14
	Little Falls	P	17	17	21	28
	Mankato	P	6	6	15	12
	Minneapolis	P	13	13	13	17

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period December 1970 through November 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES: continued						
Minn.	Rochester	P	10	8	20	13
	Worthington	P	6	5	0	0
Miss:	Jackson*	P	NA	12	0	9
Mo:	Kansas City*	P	NA	8	0	6
	St. Louis*	P	NA	6	0	5
Mont:	Helena*	P	NA	6	18	12
Nebr:	Omaha*	P	NA	7	0	4
Nev:	Las Vegas*	P	NA	2	0	1
N.H:	Manchester*	P	NA	8	11	20
N.J:	Trenton*	P	NA	8	0	10
N. Mex:	Albuquerque*	P	NA	8	0	0
N.Y:	Buffalo*	P	6	7	0	10
	New York City*	P	NA	3	13	12
	Syracuse*	P	NA	7	0	10
	Albany	P	9	0	<0 (3)	<0
	Buffalo	P	<0	<7	<0	<0
	Massena	P	8	7	<0 (2)	20
	New York City	P	6	7	<0	<0
	Syracuse	P	<0	5	<0	<0
N.C:	Charlotte*	P	NA	11	15	12
N. Dak:	Minot*	P	NA	9	20	12
Ohio:	Cincinnati*	P	NA	7	0	2
	Cleveland*	P	NA	7	0	8
Okla:	Oklahoma City*	P	NA	6	21	10
Oreg:	Portland*	P	4	5	0	7
	Baker	P	NA	3	<0	4
	Coos Bay	P	3	4	<0	7
	Eugene	P	0	2	<0	2
	Medford	P	2	2	<0	3
	Portland composite	P	NA	6	NA	6
	Portland local	P	NA	4	NA	10
	Redmond	P	2	3	<0	2
	Tillamook	P	NA	5	25	15
Pa:	Philadelphia*	P	NA	8	0	8
	Pittsburgh*	P	NA	11	0	10
	Dauphin	P	25	8	15	12
	Erie	P	3	6	19	16
	Philadelphia	P	8	8	22	17
	Pittsburgh	P	0	8	9	15
R.I:	Providence*	P	NA	8	12	16
S.C:	Charleston*	P	9	9	11	14
S. Dak:	Rapid City*	P	NA	6	0	5
Tenn:	Chattanooga*	P	NA	9	12	10
	Memphis*	P	NA	7	0	9
	Chattanooga	P	8	9	12	15
	Clinton	R	9	9	13 (2)	14
	Fayetteville	R	NS	1	NS	11
	Kingston	R	7	7	6 (2)	12
	Knoxville	P	7	7	14	12
	Lawrenceburg	R	6	5	0 (2)	3
	Nashville	P	7	7	0 (2)	10
	Pulaski	R	8	8	0	2
Tex:	Austin*	P	NA	1	0	0
	Dallas*	P	NS	6	NS	6
	Amarillo	R	NS	3	NS	2
	Corpus Christi	R	6	5	0	0
	El Paso	R	2	3	0	0
	Fort Worth	R	NS	4	NS	0
	Harlingen	R	NS	3	NS	0
	Houston	R	NS	8	NS	11
	Lubbock	R	2	3	0	0
	Midland	R	NS	3	NS	0
	San Antonio	R	NS	4	NS	0
	Texarkana	R	NS		NS	
	Tyler	R	8	13	0	12
	Uvalde	R	NS		NS	
	Wichita Falls	R	6	7	0	4
Utah:	Salt Lake City*	P	5	5	0	13
Vt:	Burlington*	P	NA	6	0	12
Va:	Norfolk*	P	NA	9	0	6
Wash:	Seattle*	P	NA	5	12	5
	Spokane*	P	NA	6	15	4
	Benton County	R	3	1	0	0
	Franklin County	R	NS	4	NS	0
	Sandpoint, Idaho	R	11	13	20	22
	Skagit County	R	7	8	19	13
W. Va:	Charleston*	P	NA	7	0	8
Wisc:	Milwaukee*	P	NA	6	0	10
Wyo:	Laramie*	P	NA	4	12	12

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1971 and 12-month period, December 1970 through November 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:						
Alberta:	Calgary	P	NA		18	21
	Edmonton	P	NA		17	24
British Columbia:	Vancouver	P	NA		22	24
Manitoba:	Winnipeg	P	NA		19	23
New Brunswick:	Fredericton	P	NA		22	24
Newfoundland:	St. John's	P	NA		22	31
Nova Scotia:	Halifax	P	NA		23	24
Ontario:	Ottawa	P	NA		32	33
	Sault Ste. Marie	P	NA		20	25
	Thunder Bay	P	NA		16	15
	Toronto	P	NA		17	14
	Windsor	P	NA		4	11
Quebec:	Montreal	P	NA		13	19
	Quebec	P	NA		26	30
Saskatchewan:	Regina	P	NA		16	15
	Saskatoon	P	NA		16	18
CENTRAL AND SOUTH AMERICA:						
Colombia:	Bogota	P	2	2	0	0
Chile:	Santiago	P	0	0	0	2
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Mandeville	P	4	5	65	80
Venezuela:	Caracas	P	0	0	0	0
Canal Zone:	Cristobal[e]	P	NA	1	11	8
Puerto Rico:	San Juan[e]	P	NA	4	17	12
PMN network average[f]			7	7	6	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [e].
NA, no analysis.
NS, no sample collected.

which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

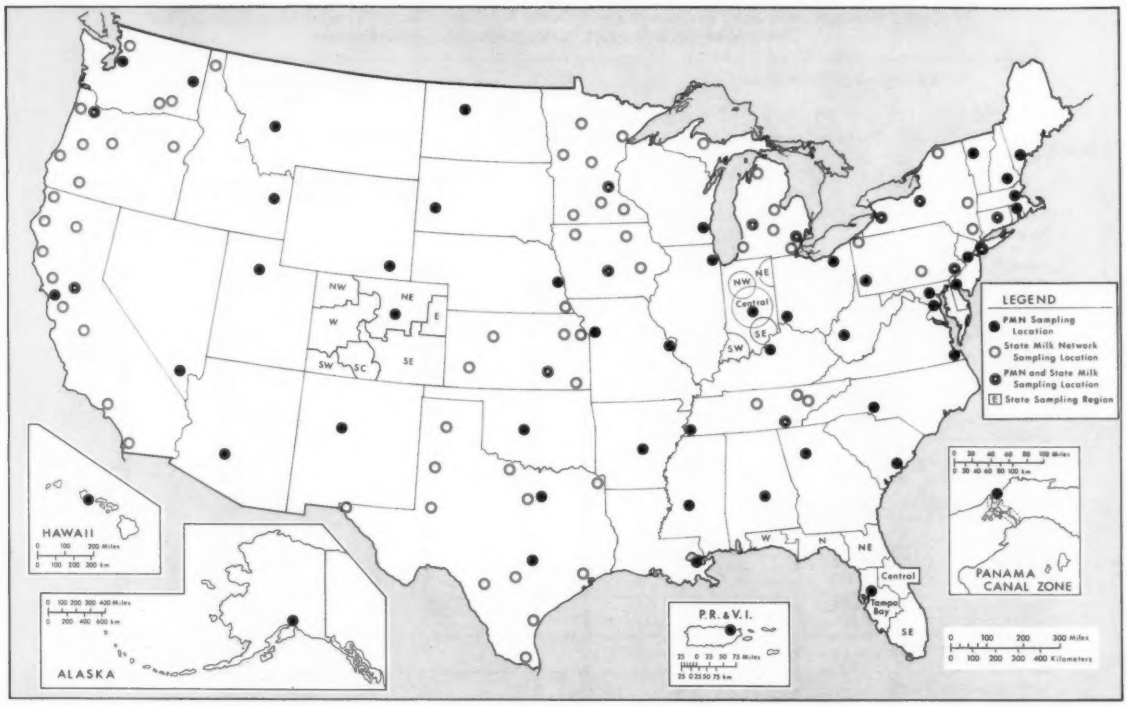

Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for November 1971 and the 12-month period, December 1970 to November 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for November 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 25 pCi/liter in the United States for November 1971, and the highest 12-month average was 17 pCi/liter (Duluth, Little Falls, Minn. (State)), representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 70 pCi/liter in the United States for November 1971, and the highest 12-month average was 54 pCi/liter (Southeast Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Table 3. Strontium-89, iodine-131, and barium-140 in milk, November 1971 [a]

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Alaska:	Palmer (PMN)	7	
Kans:	Hays (State)	5	
Tenn:	Kansas City (State)	6	
	Clinton (State)		6

[a] No iodine-131 was detected.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 in Total Diet and Milk	January–June 1971	December 1971
Connecticut Standard Diet	January–December 1970	December 1971
Institutional Total Diet	April–June 1971	November 1971
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	June 1971	February 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1970	December 1971
Minnesota	January–June 1970	November 1971
North Carolina	January–December 1967	May 1969
New York	July 1969–June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Radiostrontiumin Tap Water, HASL	January–June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April–June 1971	November 1971
Washington	July 1968–June 1969	February 1971

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE, Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Gross Radioactivity in Surface Waters of the United States July 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from six rivers during July 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements. Additional water samples for March 1971 that were

Table 1. Gross radioactivity in U.S. surface waters, July 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Big Horn River: Hardin, Mont	[a]1	<.2	2	<1	25
Clinch River: Kingston, Tenn	[b]2	<.2 (<.2-<.2)	<.2 (<.2-<.2)	2 (1-3)	4 (3-5)
Mississippi River: Burlington, Iowa	[a]1	3	1	15	8
Ohio River: Cincinnati, Ohio	[b]4	<1.0 (<.2-2)	<4.0 (<.2-5)	3.2 (1-4)	8.3 (7-9)
Roanoke River: John Kerr Dam, Va	[b]4	<.2 (<.2-<.2)	<.4 (<.2-1)	<1.6 (<.2-2)	5.8 (5-6)
St. Lawrence River: Massena, N.Y	[b]2	<.2 (<.2-<.2)	<1.6 (<.2-3)	3 (3-3)	6 (6-6)

[a] Indicates single monthly grab samples.
[b] Where more than one sample is analyzed during the month, the minimum and maximum values are in parentheses.

Table 2. Gross radioactivity in U.S. surface waters, March 1971

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Arkansas River:					
Ponca City, Okla	[a]1	1	3	6	8
Mississippi River:					
West Memphis, Ark	[a]1	6	1	19	7
Vicksburg, Miss. No. 2	[a]1	8	<.2	25	5
Vicksburg, Miss	[a]1	1	<.2	6	5
Red River:					
Denison, Tex	[a]1	<.2	<.2	<1	7
Index, Ark	[a]1	2	1	9	11
Rio Grande:					
El Paso, Tex	[a]1	6	8	33	39
Laredo, Tex	[a]1	1	5	7	20
Brownsville, Tex	[a]1	<.2	2	2	8
Sabine River:					
Ruliff, Tex	[a]1	1	<.2	4	5
Trinity River:					
Livingston, Tex	[a]1	1	<.2	5	13
Verdigris River:					
Nowata, Okla	[a]1	1	2	6	4

[a] Indicates a composited sample for second quarter ending in March 1971 of the 1971 Water Year.

omitted from the November 1971 issue of *Radiological Health Data and Reports* are shown in table 2.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radioactivity in Surface Waters of the Colorado River Basin, Radium Monitoring Network, 1968 [1]

Colorado River Basin Water Quality Control Project
Environmental Protection Agency

The Radium Monitoring Network is a surface water surveillance system currently consisting of 20 sampling stations located throughout the Colorado River Basin (figure 1). The purpose of this network is to provide a continuous assay of basin river water radioactivity resulting primarily from uranium milling and milling industry waste discharges. The analyses for gross alpha, gross beta, thorium alpha, lead-210, polonium-210, and strontium-90 have been performed on samples from selected sampling stations since July 1963.

Sampling procedures

Depending on individual station parameters, Radium Monitoring Network (RMN) samples are collected as either automatic or grab samples. Grab samples are collected once or three times per week and automatic samplers collect 21 milliliter portions every hour. The samples are sent as collected to the Colorado River Basin Water Quality Control Project Laboratory where they are composited, filtered and analyzed for the desired radionuclides.

Radium-226 with the lowest recommended maximum permissible concentration in water of all radionuclides, has been the radioactive contaminant of greatest concern in uranium discharges. Consequently, initial and primary emphasis was placed on the analysis for radium only. In October 1963, uranium determinations were added. Beginning in July 1963, samples from selected stations were combined into quarterly composites for gamma-ray spectroscopy and analyzed for gross alpha, gross beta, strontium-90, thorium alpha, and lead-210 radioactivities. Some determinations for polonium-210 were also performed.

Analytical methods

Water samples are composited and filtered through 0.45 micron-membrane filters as soon as possible after the samples for the compositing period are received. After filtration, samples are acidified with a 2 percent by volume 12 *N* hydrochloric acid and radiochemical determinations are then performed on the filtered water.

Radium-226 is determined by an emanation method (*1*). Lead-210 is determined by an iodine-dithiozone extraction method (*2*). Uranium is determined by a fluorometric method, using a sodium carbonate-potassium carbonate-sodium fluoride flux (*3*). Gross alpha and beta radioactivity determinations are made on dried dissolved solids from the waters, using appropriate correction factors for self-absorption (*4*). Strontium-90 is isolated by coprecipitation with calcium and magnesium carbonate (*5*). It is absorbed in an ion exchange column and the yttrium-90 which grows in is eluted and measured. Polonium-210 is determined by the method described in reference (*6*). Gross gamma-ray determinations are done using a sodium iodide crystal as a detector in combination with a multichannel analyzer and a scaler as the recording device.

[1] Summarized from "Radium Monitoring Network Data," release numbers 13, 14, and 15.

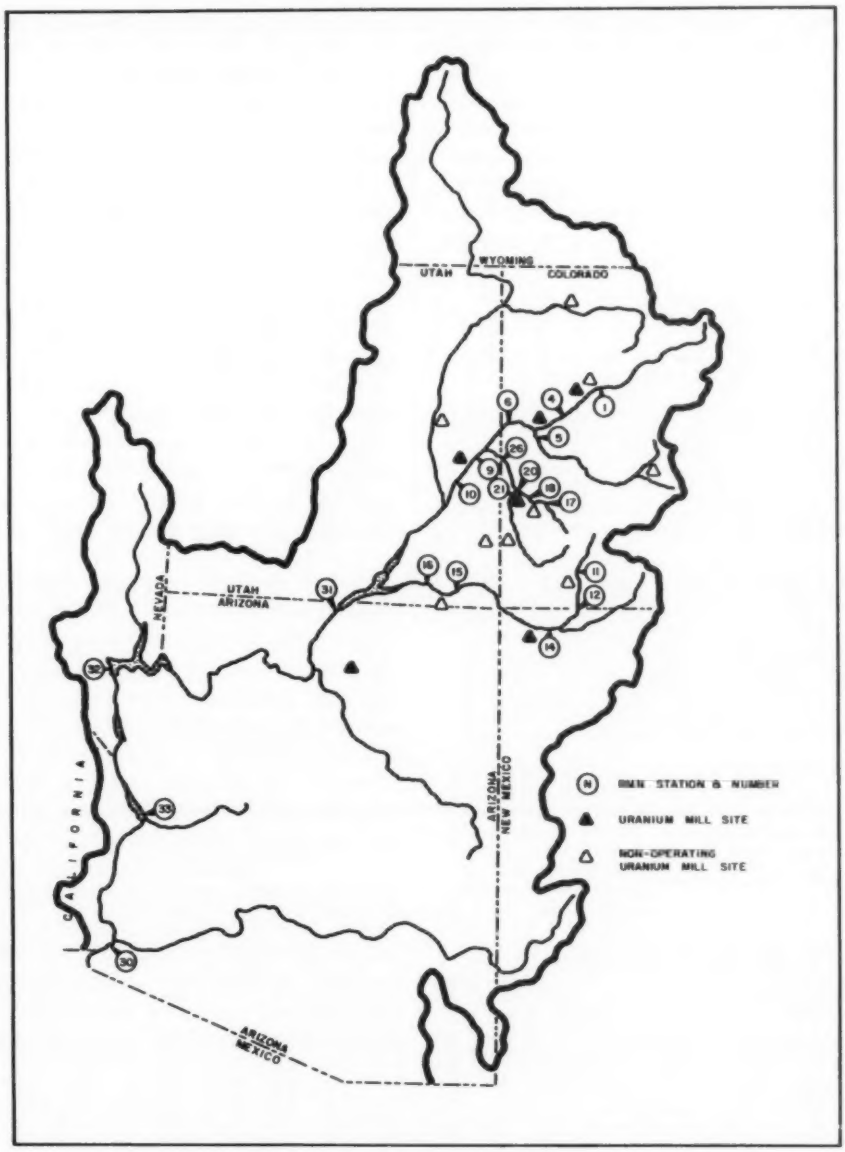

Figure 1. Colorado River Basin radium monitoring network

Alpha-particle emitting thorium isotopes are determined by coprecipitation with ferric hydroxide and yttrium fluoride followed by extraction with thenoyltrifluoroacetone, mounting, and alpha-particle counting.

Results

Radium-226 concentrations at all stations except station 20 continue to average well below recommended maximum concentrations. A summary of radium-226 and uranium determina-

Table 1. Radium-226 in surface waters of the Colorado River basin, January–December 1968

Sampling station number and location	Concentration (dissolved) (pg/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly average
Animas River:													
#11 above Durango, Colo	0.05	0.05	0.05	0.04	0.07	0.03	0.06	0.05	0.03	0.04	0.04	0.04	0.05
#12 Colo.-N. Mex. State line	.09	.07	.10	.05	.06	.06	.04	NS	NS	NS	NS	NS	.07
Colorado River:													
#1 at Silt, Colo	.25	.23	.27	.22	.08	.05	.13	.10	.22	.23	.21	.27	.18
#4 at De Beque, Colo	.25	.23	.22	.19	.12	.06	.12	.12	.19	.22	.21	.17	.18
#6 at Fruita, Colo	.14	.13	.16	.15	.22	.09	.13	.16	.13	.14	.13	.14	.14
#9 above Moab, Utah	.32	.26	.24	.43	.21	.20	.27	.29	.22	.16	.16	.19	.25
#10 below Moab, Utah	.72	.57	1.3	.42	.38	.38	.31	.26	.36	.31	.23	.24	.46
#31 at Page, Ariz	.13	.16	.15	.20	.17	.16	.15	.23	.18	.13	.15	.16	.17
#32 Lake Mead, Nev	.26	.23	.23	.25	.19	.20	.23	.27	.26	.17	.20	.21	.23
#33 Lake Havasu, Calif	.28	.28	.28	.26	.26	.18	.26	.24	.31	.24	NS	NS	.26
#30 at Yuma, Ariz	.17	.12	.15	.20	.10	.13	.18	.22	.13	.09	.10	.11	.14
Delores River:													
#21 at Bedrock, Colo	.33	.16	.39	.16	.14	.11	.23	.39	.41	.55	.44	.31	.30
#26 at Gateway, Colo	2.7	3.8	2.9	.78	.21	.44	.88	.94	3.6	2.1	1.5	1.7	1.80
Gunnison River:													
#5 at Grand Junction, Colo	.08	.04	.04	.05	.05	.04	.16	.17	.09	.10	.09	.08	.08
San Juan River:													
#14 below Farmington, N. Mex	.08	.05	.06	.07	.05	.07	.08	.05	.06	.05	.05	.03	.06
#15 above Mexican Hat, Utah	NS	.09	.08	.07	.15	.05	NS	NS	NS	NS	NS	NS	.09
#16 below Mexican Hat, Utah	NS	.08	.06	.06	.10	.06	NS	NS	NS	NS	NS	NS	.07
San Miguel River:													
#17 above Naturita, Colo	.04	.02	.03	.05	.04	.02	.04	.03	.06	.04	.01	.04	.04
#18 above Uravan, Colo	.09	.09	.11	.16	.09	.11	.11	.10	.13	.09	.12	.06	.11
#20 below Uravan, Colo	8.14	4.9	5.9	2.18	.59	.96	1.00	1.34	2.83	1.25	3.29	9.7	[a]3.40

[a] Mean of 52 separate analyses.
NS, no sample.

Table 2. Uranium in surface waters of the Colorado River basin, January–December 1968

Sampling station number and location	Concentration (dissolved) (μg/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly average
Animas River:													
#11 above Durango, Colo	1.2	1.4	1.2	1.1	1.4	0.3	1.5	0.6	2.0	3.1	3.2	2.2	1.6
#12 Colo.-N. Mex. State line	2.5	2.6	2.4	1.8	1.2	.8	2.8	NS	NS	NS	NS	NS	2.0
Colorado River:													
#1 at Silt, Colo	3.5	3.2	3.3	2.7	.8	1.9	2.7	1.6	3.7	4.9	5.0	5.3	3.2
#4 at De Beque, Colo	5.5	4.6	4.7	3.7	1.5	2.5	2.9	1.7	3.7	5.4	6.6	6.1	4.1
#6 at Fruita, Colo	7.5	8.1	7.9	6.6	4.3	3.9	7.2	5.8	11	13	9.1	8.7	7.8
#9 above Moab, Utah	9.3	9.1	10	8.8	4.9	2.0	6.0	8.0	14	12	7.9	9.6	8.5
#10 below Moab, Utah	10	10	12	11	6.0	2.2	8.8	8.2	15	14	13	9.4	10.0
#31 at Page, Ariz	6.8	7.4	7.4	7.0	7.9	8.3	6.1	3.7	5.6	7.2	6.8	6.5	6.7
#32 Lake Mead, Nev	7.0	7.8	6.8	7.2	6.5	7.1	6.1	5.5	7.5	8.6	8.9	8.3	7.3
#33 Lake Havasu, Calif	7.3	7.6	6.6	7.0	7.2	7.4	5.7	5.8	7.2	9.3	NS	NS	7.1
#30 at Yuma, Ariz	7.2	7.4	7.5	7.9	6.4	7.7	7.6	5.7	6.6	6.8	7.3	7.5	7.1
Delores River:													
#21 at Bedrock, Colo	7.4	7.0	8.5	3.8	1.6	.8	6.2	3.9	11	18	13	12	7.8
#26 at Gateway, Colo	25	31	23	15	5.7	6.0	8.2	15	32	36	24	40	21.7
Gunnison River:													
#5 at Grand Junction, Colo	10	7.7	11	6.8	3.4	5.1	14	10	15	14	8.9	7.3	9.4
San Juan River:													
#14 below Farmington, N. Mex	3.7	2.7	3.2	1.7	1.4	.8	2.9	2.3	4.1	4.5	4.5	2.7	2.9
#15 above Mexican Hat, Utah	NS	6.0	6.9	4.3	2.4	1.0	NS	NS	NS	NS	NS	NS	4.1
#16 below Mexican Hat, Utah	NS	6.6	6.3	5.0	2.8	1.2	NS	NS	NS	NS	NS	NS	4.4
San Miguel River:													
#17 above Naturita, Colo	2.8	3.3	3.3	1.6	1.6	.8	.7	.6	6.9	8.2	4.4	4.3	3.2
#18 above Uravan, Colo	5.2	5.0	4.4	3.4	1.4	.9	1.5	1.5	7.5	8.4	7.1	5.7	4.3
#20 below Uravan, Colo	46.7	9.9	10.1	8.1	3.4	1.0	10.9	26.8	27.5	29.4	48	86	[a]25.0

[a] Mean of 52 separate analyses.
NS, no sample.

tions on RMN samples for 1968 is given in tables 1 and 2. Compared with results from the previous reporting period, 15 stations showed lower or unchanged concentrations of radium-226. Radium-226 concentrations at five stations showed significant percentage increases, but only two of these increases are regarded as significant because of the absolute concentrations involved.

Lead-210, polonium-210, and thorium (alpha) concentrations, while detectable in some of the quarterly composited samples, have been of no significance insofar as health hazards are concerned. Generally, higher concentrations were observed below the uranium mill at Uravan, Colo., than at other stations for which data were available. Gross alpha and gross beta radioactivity concentrations also are generally higher at the same station.

Stations located above and below the uranium mill at Moab, Utah, showed higher concentrations of gross alpha and gross beta radioactivities than did the other stations, except the one below Uravan. However, at Moab, the difference in the upstream and downstream averages is not striking. None of the gross alpha and gross beta results indicates a potential hazard aside from the possible inclusion of radium-226 and strontium-90 in the gross figures for alpha and beta.

Radium-226 concentrations (dissolved) in samples from the San Miguel River downstream of the uranium mill at Uravan, Colo., average 3.40 picograms per liter in 1968 as compared with annual averages for the two previous years of 1.57 (1967) and 1.93 (1966) picograms per liter and a mean of 1.18 from 1961 through 1967. At Gateway, Colo., on the Dolores River downstream of its confluence with the San Miguel, the radium-226 concentrations (dissolved) in water samples averaged 1.80 picograms per liter as compared with 1.22 and 1.20 picograms per liter for 1967 and 1966, respectively.

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(*2*) TALVITIE, N. A. and W. J. GARCIA. Radiochemical determinations of lead-210 after solvent extraction as iodide and dithizonate. Anal Chem 37: 854 (1965).

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(*6*) RUSHING, D. E. Determination of dissolved polonium-210 in water by coprecipitation with tellurium by stannous chloride. Anal Chem 38:900 (June 1966).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1967	December 1968

Radioactivity in Washington Surface Water[1] July 1969-June 1970

Washington State Department of Social and Health Services

Radioanalysis of surface water samples collected throughout the State is one of the major functions of the Washington State Department of Social and Health Services radiation surveillance program. Some surface water samples are collected monthly or quarterly by the Washington State Department of Ecology. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department. Figure 1 shows the surface water sampling locations and code numbers.

All water is collected in 2-liter polyethylene bottles by grab sampling and is mailed to the State radiation laboratory in Seattle for analysis. Before sampling, 2 milliliters of concentrated nitric acid are added to each bottle to prevent loss of radioactivity through precipitation or adhesion.

Analytical procedures

Surface water samples are analyzed for gamma-ray emitters and then separated into

[1] Summarized from "Environmental Radiation Surveillance in Washington State," Ninth Annual Repuort, July 1969–June 1970.

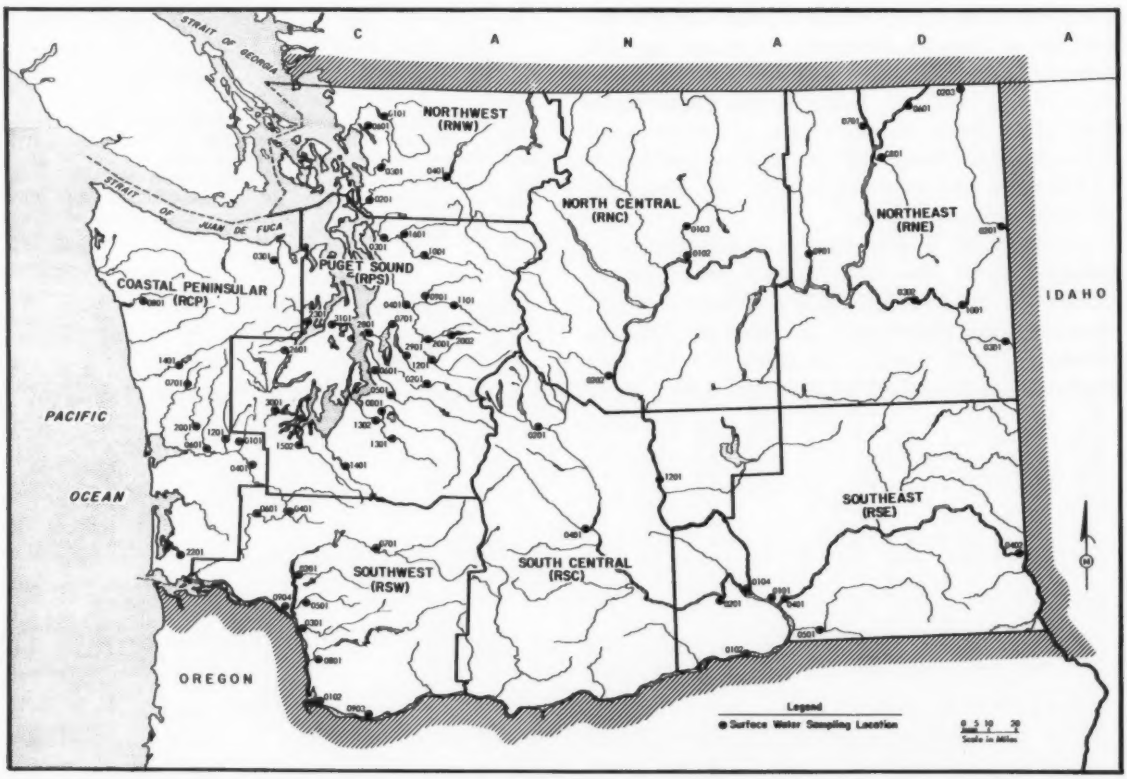

Figure 1. Washington State surface water sampling locations with code numbers

suspended and soluble fractions for gross beta counting. All Columbia River samples are also analyzed for phosphorus-32, a pure beta-particle emitter which is not detectable in the gamma-ray scan. Table 1 gives the beta-particle efficiencies and detectable limits for the beta counters.

Table 1. Beta-particle efficiencies and detectability limits for the Washington State analysis

Radionuclide	Efficiency (percent)	Average background (cpm)	Detectability limits[a] (pCi)
Strontium-yttrium-90	47	0.8	0.25
Yttrium-90	51	.8	.23
Phosphorus-32	48	.8	.24

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.

For the gamma radioanalysis, the samples are placed in stainless-steel Marinelli beakers as soon after receipt as possible. Distilled water is added when necessary to obtain 2,000 ml geometry. Table 2 presents the gamma-ray efficiencies and detectability limits for the gamma spectrometer. After analysis by gamma spectroscopy, surface water (except Columbia River) is filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace at 600° C., plancheted, weighed, and submitted for gross beta counting. The filtrate, evaporated to near dryness, is quantatively transferred to a tared planchet, dried, weighed, and submitted for gross beta counting.

Table 2. Gamma-ray efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits[a] (pCi)
Chromium-51	0.30–0.36	0.52	22.82	200
Ruthenium-106	.44– .56	.91	21.61	100
Scandium-46	.86– .92	2.45	4.71	20
Zirconium-95	.73– .79	6.96	5.68	10
Zinc-65	1.05–1.17	1.06	6.30	40

[a] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

The gamma analysis of the Columbia River samples is started approximately 14 days after collection. After the gamma spectroscopic analysis, Columbia River samples are divided into two aliquots. One aliquot is prepared for standard gross beta counting as described above, while the second aliquot is prepared for phosphorus-32 counting. The technique used for phosphorus-32 separation is a modification of published methods (*1-4*). After a waiting period of 15 days following collection to allow arsenic-76 and other short-lived interfering radionuclides to decay, the phosphorus is separated from the interfering radionuclides by precipitation as ammonium phosphomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3N ammonium hydroxide, transferred into a tared planchet, dried, ashed at 450° C., weighed, and counted for beta radioactivity.

Results

Table 3 presents the monthly average results for six Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 4 summarizes the beta radioactivity measurements from 5 other surface water stations from July 1969 through June 1970.

Table 5 presents the individual sample results from the tritium analyses performed by WERL for the State of Washington.

Discussion

Of the 50 river water samples analyzed from July 1969 through June 1970 (excluding the Columbia River), the total beta radioactivity ranged from <1 to 12 pCi/liter. The numerous sample results below the detectability limit of 1 pCi/liter precluded the determination of a precise average for comparison with previous years' data. Figure 2 shows the annual maximum and average gross beta radioactivity in surface waters other than the Columbia River for June 1963 through June 1970. The plotted average of 2.6 pCi/liter for 1970 actually is more representative of an upper limit based on the data shown in table 4.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford facility ranged from 2 to 373 pCi/liter. Monthly average concentrations of the beta emitter

Table 3. Monthly average radioactivity in Columbia River water, July 1969–June 1970

Location and type of analysis	Concentration (pCi/liter)											
	1969						1970					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Northport (code No. RNE 0601)												
Beta-particle												
Suspended[a]	NS	<1	NS	NS	<1	NS	NS	<1	NS	NS	<1	NS
Dissolved[a]	NS	3	NS	NS	2	NS	NS	2	NS	NS	2	NS
Total	NS	3	NS	NS	2	NS	NS	2	NS	NS	2	NS
Phosphorus-32[b]	NS	<1	NS	NS	<1	NS	NS	<1	NS	NS	<1	NS
Gamma-ray[b]												
Chromium-51	NS	<100	NS	NS	<100	NS	NS	<100	NS	NS	<100	NS
Zinc-65	NS	<20	NS	NS	<20	NS	NS	<20	NS	NS	<20	NS
Scandium-46	NS	<10	NS	NS	<10	NS	NS	<10	NS	NS	<10	NS
Richland (code No. RSE 0104)												
Beta-particle												
Suspended[a]	34 (4)	48 (4)	163 (5)	27 (3)	274 (4)	160 (5)	150 (4)	99 (4)	195 (5)	77 (3)	136 (4)	29 (5)
Dissolved[a]	48 (4)	82 (4)	118 (5)	148 (4)	99 (4)	101 (5)	88 (4)	16 (4)	45 (5)	58 (3)	55 (4)	29 (5)
Total	82	130	281	175	373	261	238	115	240	135	191	58
Phosphorus-32[b]	34 (4)	35 (4)	85 (5)	81 (4)	72 (4)	57 (5)	56 (4)	16 (4)	10 (5)	43 (3)	51 (4)	20 (5)
Gamma-ray[b]												
Chromium-51	682 (4)	1,398 (4)	1,271 (5)	2,362 (4)	1,362 (4)	1,044 (5)	1,190 (4)	317 (4)	349 (5)	580 (3)	698 (4)	290 (5)
Zinc-65	38 (4)	51 (4)	178 (5)	194 (4)	131 (4)	106 (5)	162 (4)	65 (4)	162 (5)	87 (3)	180 (4)	46 (5)
Scandium-46	64 (4)	77 (4)	255 (5)	917 (4)	301 (4)	233 (5)	602 (4)	110 (4)	434 (5)	136 (3)	724 (4)	98 (5)
Pasco (code No. RSE 0101)												
Beta-particle												
Suspended[a]	14	36	57	30	66	37	16	42	3	13	42	8
Dissolved[a]	17	33	37	56	68	55	30	22	5	12	48	15
Total	31	69	94	86	134	92	46	64	8	25	90	23
Phosphorus-32[b]	14	30	21	54	61	58	23	6	<1	6	56	10
Gamma-ray[b]												
Chromium-51	238	472	250	728	906	872	341	<100	<100	<100	530	200
Zinc-65	38	46	62	54	75	93	<20	31	26	38	72	<20
Scandium-46	21	55	142	85	115	109	44	66	<10	29	49	<10
McNary Dam (code No. RSE 0102)												
Beta-particle												
Suspended[a]	4	8	13	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved[a]	5	13	27	NS	NS	NS	NS	NS	NS	NS	NS	NS
Total	9	21	40	NS	NS	NS	NS	NS	NS	NS	NS	NS
Phosphorus-32[b]	2	10	28	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	<100	234	403	NS	NS	NS	NS	NS	NS	NS	NS	NS
Zinc-65	<20	<20	26	NS	NS	NS	NS	NS	NS	NS	NS	NS
Scandium-46	<10	<10	17	NS	NS	NS	NS	NS	NS	NS	NS	NS
Vancouver (code No. RSW 0102)												
Beta-particle												
Suspended[a]	8	3	4	3	2	NS	NS	NS	NS	NS	NS	NS
Dissolved[a]	10	6	11	11	9	NS	NS	NS	NS	NS	NS	NS
Total	18	9	15	14	11	NS	NS	NS	NS	NS	NS	NS
Phosphorus-32[b]	9	3	4	6	8	NS	NS	NS	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	197	131	278	307	143	NS	NS	NS	NS	NS	NS	NS
Zinc-65	<20	<20	<20	<20	<20	NS	NS	NS	NS	NS	NS	NS
Scandium-46	<10	<10	<10	<10	<10	NS	NS	NS	NS	NS	NS	NS
Longview (code No. RSW 0904)												
Beta-particle												
Suspended[a]	5	2	2	2	2	2	2	3	1	1	5	5
Dissolved[a]	7	5	7	9	6	6	5	5	3	3	7	6
Total	12	7	9	11	8	8	7	8	4	4	12	11
Phosphorus-32[b]	2	2	4	5	4	4	3	3	<1	1	5	3
Gamma-ray[b]												
Chromium-51	150	147	214	209	117	148	119	100	<100	<100	157	<100
Zinc-65	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	25	<20
Scandium-46	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

[a] Activity at time of counting. Strontium-90 yttrium-90 calibration standard.
[b] Results extrapolated to date of sample collection.
NS, no sample.

phosphorus-32 ranged from <1 to 85 pCi/liter. Figures 3 and 4 show the gross beta and phosphorus-32 results from the Columbia River at Pasco and Vancouver for 1963 through June 1970.

Monthly averages for chromium-51 ranged from <100 to 2,362 pCi/liter, and for zinc-65 the range was <20 to 194 pCi/liter. Figures 5 and 6 show the results for chromium-51 and zinc-65 at the Pasco and Vancouver stations on

Table 4. Beta radioactivity in Washington surface water [a] (except for Columbia River), July 1969–June 1970

Sampling location	Concentrations (pCi/liter)											
	1969						1970					
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Cedar River:												
Landberg												
Suspended	<1	<1	<1	<1	<1	<1	<1	<1	<1 (2)	<1	<1	<1
Dissolved	<1	<1	1	<1	<1	1	<1	1	<1 (2)	<1	<1	1
Lake Whatcom:												
Bellingham												
Suspended	<1	<1	<1	NS	<1	<1	<1	<1	<1	<1	<1	1
Dissolved	3	2	3	NS	2	3	2	2	2	2	2	2
Puyallup River:												
Puyallup												
Suspended	<1	3	2	NS	<1	<1	<1	<1	<1	<1	<1	10
Dissolved	2	2	2	NS	2	2	1	1	1	2	1	2
Snake River:												
Pasco												
Suspended	<1	<1	<1	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dissolved	2	7	4	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spokane River:												
Long Lake												
Suspended	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved	2	2	2	3	2	3	2	2	2	2	2	2

[a] Activity at time of counting. Strontium-yttrium–90 calibration standard. No detectable gamma activity present.
NS, no sample.

Table 5. Tritium in Washington surface water [a] July 1969–June 1970

Sampling location	Collection date (1969)	Concentration (nCi/liter)
Cedar River:		
Landsberg	8/22	<0.40
	11/21	.43
Columbia River:		
Longview	8/ 6	.50
	11/ 5	.69
McNary Dam	8/19	.89
Pasco	8/ 6	.93
	11/ 6	1.00
Richland	8/ 4	.95
	11/ 3	1.00
Vancouver	8/ 6	.84
	11/17	.91
Lake Whatcom:		
Bellingham	8/11	.75
	11/11	<.40
Snake River:		
Pasco	8/19	.50
Spokane River:		
Long Lake	8/ 9	.76
	11/16	.61

[a] Analyses performed by WERL, Las Vegas, Nev.

the Columbia River for 1963 through June 1970.

It should be emphasized the radionuclide concentrations found in the Columbia River cannot be extrapolated to the radiation discharges from modern nuclear power reactors. The concentrations in the Columbia River are due largely to old (up to 25 years) first technology plutonium production reactors utilizing direct single-pass cooling and do not reflect the environmental effects that would result from modern reactors.

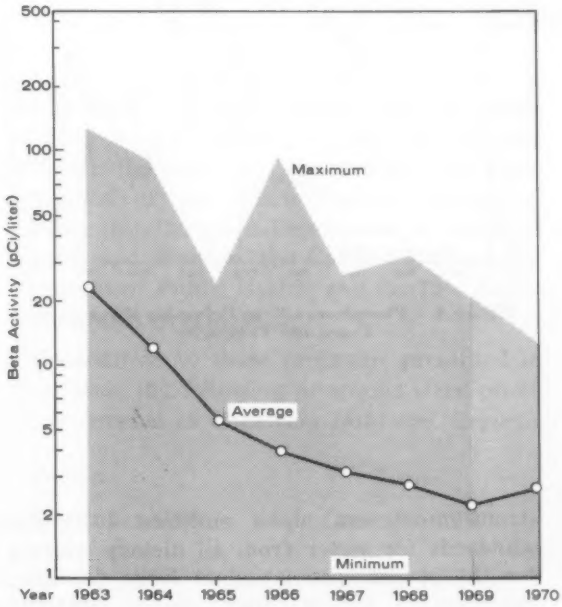

Figure 2. Average, maximum, and minimum beta radioactivity in surface water (excluding the Columbia River), 1963–1970

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1 nCi/liter of gross beta radioactivity in the absence of

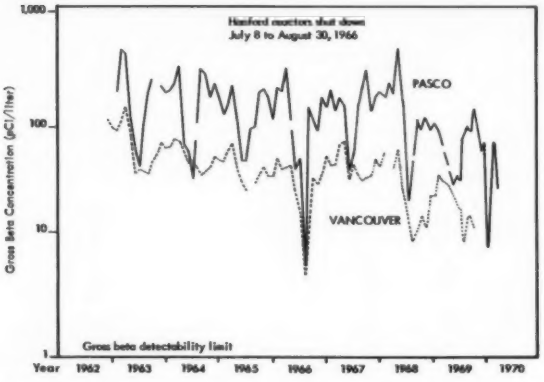

Figure 3. Gross beta radioactivity in Columbia River water, Pasco and Vancouver

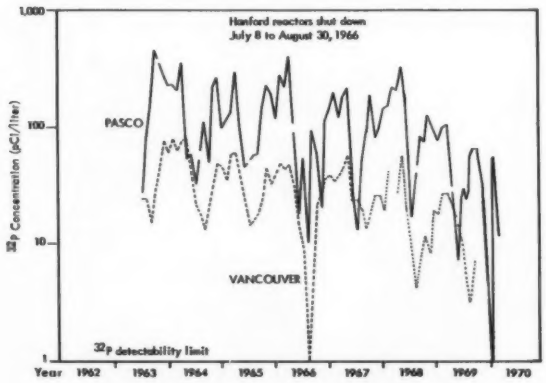

Figure 4. Phosphorus-32 in Columbia River water Pasco and Vancouver

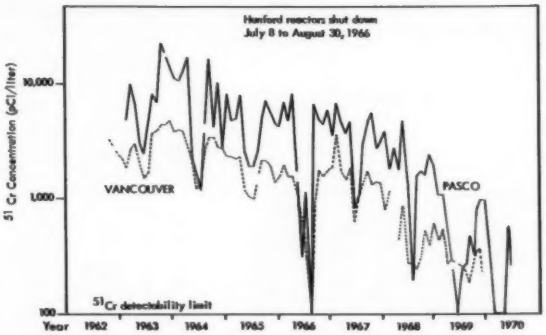

Figure 5. Chromium-51 in Columbia River water Pasco and Vancouver

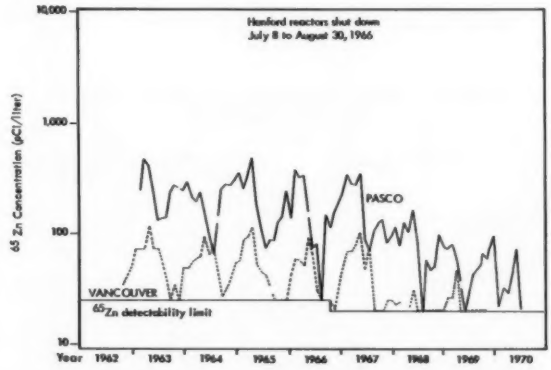

Figure 6. Zinc-65 in Columbia River water Pasco and Vancouver

strontium-90 and alpha emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are: chromium-51, 670 nCi/liter; zinc-65, 10 nCi/liter; and phosphorus-32, 7 nCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1968–June 1969	February 1971

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California State Department of Public Health, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican Air Monitoring Program	August–December 1970 and January 1971	October 1971
Plutonium in Airborne Particulates	January–March 1971	November 1971
Surface Air Sampling Program 80th Meridian Network, *HASL*	January–December 1969	January 1972

1. Radiation Alert Network November 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1971.

Higher than normal readings were reported for some stations, but none were reported higher than 17 pCi/m^3.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	17	6	1	2	2	88	2	88	98
Alaska:	Anchorage	4	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	0				0				
	Juneau	12	1	0	0	0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	10	14	2	6	0				
Ark:	Little Rock	1	0	0	0	0				
Calif:	Berkeley	18	2	0	1	1	13	1	13	0
	Los Angeles	2	2	1	2	0				
C.Z:	Ancon	12	0	0	0	0				
Colo:	Denver	21	5	0	3	2	6	[b]		
Conn:	Hartford	18	1	0	0	7	61	7	61	0
Del:	Dover	20	1	0	0	0				
D.C:	Washington	26	1	0	0	0				
Fla:	Jacksonville	20	1	0	1	3	36	3	36	10
	Miami	16	0	0	0	4	98	4	98	0
Ga:	Atlanta	19	2	0	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	19	1	0	0	5	64	[b]		
Idaho:	Boise	21	4	0	2	4	55	4	55	7
Ill:	Springfield	8	2	0	1	0				
Ind:	Indianapolis	19	2	0	1	0				
Iowa:	Iowa City	20	4	0	1	4	126	4	126	0
Kans:	Topeka	19	3	0	1	7	72	7	72	3
Ky:	Frankfort	0				0				
La:	New Orleans	18	1	0	0	4	22	[b]		
Maine:	Augusta	20	2	0	0	4	59	4	59	0
Md:	Baltimore	21	2	0	0	4	38	4	38	0
Mass:	Lawrence	20	1	0	0	6	107	5	87	0
	Winchester	20	2	0	1	7	160	7	160	0
Mich:	Lansing	20	1	0	1	3	8	3	8	1
Minn:	Minneapolis	20	4	0	1	7	102	7	102	25
Miss:	Jackson	16	2	0	1	2	13	2	13	2
Mo:	Jefferson City	21	3	0	1	6	57	6	57	3
Mont:	Helena	17	2	1	1	0				
Nebr:	Lincoln	10	10	1	3	3	45	3	45	17
Nev:	Las Vegas	20	5	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	8	92	8	92	5
N. Mex:	Santa Fe	16	2	0	1	3	37	3	37	0
N.Y:	Albany	19	1	0	0	0				
	Buffalo	20	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	14	17	1	4	0				
N. Dak:	Bismarck	21	5	0	1	5	25	5	25	3
Ohio:	Cincinnati	0				0				
	Columbus	4	2	0	1	0				
	Painesville	19	2	0	1	5	59	5	59	35
Okla:	Oklahoma City	0				0				
	Ponca City	20	9	0	1	4	28	4	28	0
Oreg:	Portland	19	1	0	0	11	177	11	177	3
Pa:	Harrisburg	11	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	18	2	0	0	4	13	4	13	0
S.C:	Columbia	15	7	0	2	2	46	2	46	0
S. Dak:	Pierre	21	10	1	2	0				
Tenn:	Nashville	21	3	0	1	4	32	4	32	2
Tex:	Austin	16	6	0	2	1	16	[b]		
	El Paso	13	8	1	2	0				
Utah:	Salt Lake City	29	1	0	1	7	46	7	46	29
Vt:	Barre	20	3	0	1	7	97	7	97	9
Va:	Richmond	16	1	0	0	3	67	3	67	17
Wash:	Seattle	13	1	0	0	10	107	[b]		
	Spokane	18	1	0	0	0				
W. Va:	Charleston	21	3	0	1	9	69	9	69	9
Wisc:	Madison	19	3	0	1	6	94	6	94	18
Wyo:	Cheyenne	18	5	1	3	0				
Network summary		1,015	17	0	1	174	72	5	65	10

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] November 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare. Ottawa, Canada.

Surface air and precipitation data for November 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.2	0.0	0.1	[a]	0.4
Coral Harbour	30	.1	.0	.0	15	.3
Edmonton	30	.3	.0	.1	86	2.2
Ft. Churchill	30	.1	.0	.0	17	.4
Fredericton	30	.1	.0	.0	15	1.4
Goose Bay	30	.1	.0	.0	4	.6
Halifax	30	.1	.0	.1	15	2.4
Inuvik	30	.1	.0	.0	16	.3
Montreal	30	.1	.0	.1	27	1.5
Moosonee	30	.1	.0	.0	13	.5
Ottawa	30	.3	.0	.1	28	1.7
Quebec	30	.1	.0	.0	23	1.7
Regina	30	.6	.0	.1	109	.8
Resolute	30	.1	.0	.1	[a]	.1
St. John's, Nfld	30	.1	.0	.0	16	3.9
Saskatoon	30	.1	.0	.1	68	1.0
Sault Ste. Marie	20	.1	.0	.1	28	2.1
Thunder Bay	30	.1	.0	.0	27	2.0
Toronto	30	.2	.0	.1	30	1.3
Vancouver	30	.2	.0	.1	18	3.2
Whitehorse	30	.2	.0	.1	7	.2
Windsor	30	.1	.0	.1	25	1.3
Winnipeg	30	.1	.0	.0	43	1.0
Yellowknife	30	.1	.0	.0	35	.8
Network summary	710	0.6	0.0	0.1	30	1.3

[a] Precipitation, less than 0.1 inches.

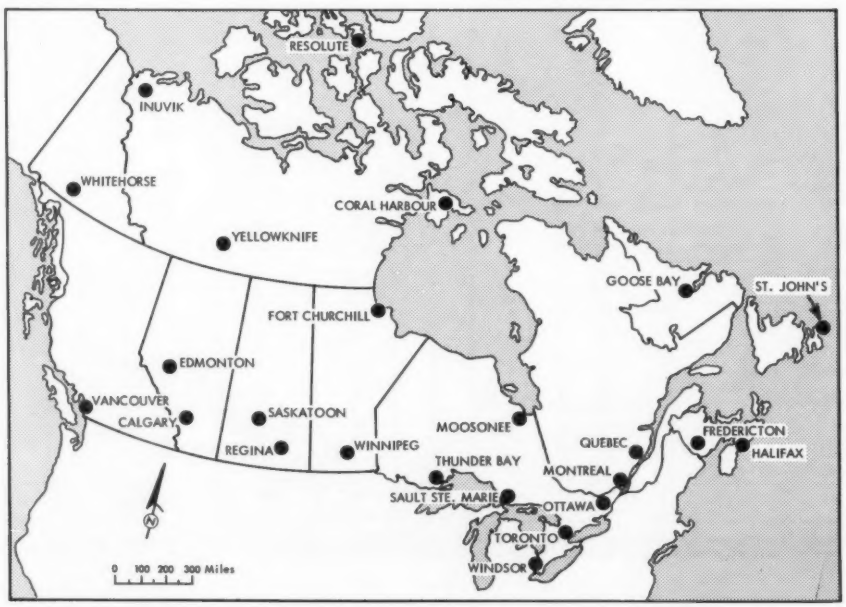

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program November 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The November 1971 air monitoring results from the participating countries are given in table 3.

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	15	0.39	0.04	0.25
Chile:	Santiago	30	.48	.08	.26
Colombia:	Bogota	20	.33	.00	.03
Ecuador:	Cuenca	4	.14	.03	.07
	Guayaquil	8	.69	.14	.40
	Quito	18	.08	.00	.02
Guyana:	Georgetown	10	.05	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	8	.49	.18	.33
Venezuela:	Caracas	20	.04	.00	.02
West Indies:	Trinidad	14	.03	.01	.02
Pan American summary		147	0.69	0.00	0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program November 1971

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47

Figure 4. California Air Sampling Program stations

millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for November 1971.

Table 4. Gross beta radioactivity in California air November 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	30	1.52	0.12	0.51
Barstow	30	20.31	.09	1.37
Berkeley	30	.37	.06	.17
Colfax	29	3.40	.04	.42
El Centro	28	2.03	.06	.57
Eureka	18	.30	.06	.16
Fresno	30	7.91	.07	.67
Los Angeles	11	1.57	.08	.61
Redding	29	1.15	.08	.22
Sacramento	30	4.22	.06	.45
Salinas	30	2.39	.06	.56
San Bernardino	30	2.57	.10	.51
San Diego	30	.71	.10	.25
Santa Rosa	30	.92	.04	.23
Summary	385	20.31	0.04	0.48

5. Plutonium in Airborne Particulates April-June 1971

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Office of Air Programs, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for April–June 1971 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 5. Plutonium in airborne particulates April–June 1971

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	$^{239}Pu/^{238}Pu$
Alaska:	Anchorage	[a]4 ±2	[a]44 ±5	[a]11 ±6
Ariz:	Phoenix	10 ±5	110 ±24	11 ±6
Colo:	Denver	9 ±5	125 ±28	14 ±8
Hawaii:	Honolulu	4 ±1	57 ±4	14 ±4
La:	New Orleans	4 ±1	75 ±7	19 ±5
Md:	Baltimore	5 ±1	82 ±10	16 ±4
N.Y:	Buffalo	5 ±2	104 ±10	21 ±9
N.C:	Gastonia	8 ±2	120 ±10	15 ±4
S.Dak:	Pierre	7 ±2	104 ±14	15 ±5
Tex:	Austin	NS		
Wash:	Seattle	7 ±3	131 ±17	19 ±8

[a] Composite of April and June only.
NS, no sample.

Recent coverage in *Radiological Health Data and Reports:*

Issue	Period
July–December 1970	June 1971
January–March 1971	November 1971

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Air Surveillance Network August-September 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network, operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

[1] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

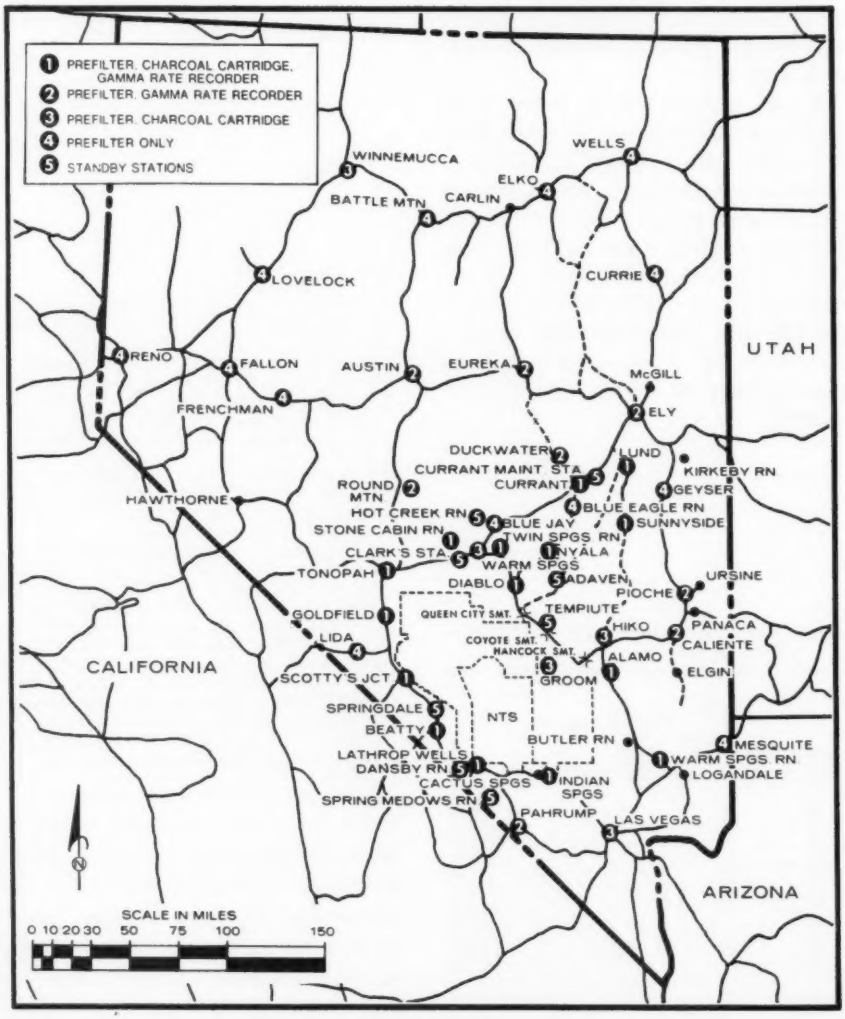

Figure 1. WERL Air Surveillance Network stations in Nevada

Sampling

Twenty-four-hour samples of airborne particulates are collected daily at each active station on 4-inch diameter, glass-fiber filters at a flow rate of about 350 m^3 of air per day. Samples may be collected for shorter periods to document specific radioactivity releases. Activated charcoal cartridges following the filters are used regularly for collection of radioiodines at 22 stations. The stations are operated by State health department personnel and by private individuals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS.

All charcoal cartridges are counted for 10 minutes in a gamma spectrometer. Data from those cartridges having a net gross gamma count rate greater than 300 cpm are analyzed by a computer matrix to quantitate individual radionuclides.

Analysis

The particulate filters are counted for gross beta activity as soon as they are received and at 5 and 12 days after collection. Samples are counted on gas-flow proportional counters calibrated over a range of beta energies from 0.1 to 1.8 MeV. A conservative efficiency value of 45 percent (corresponding to an average maximum beta energy of 0.5 MeV) is used for data conversion. Those filters with total gross beta activities of 500 cpm or greater are gamma scanned on a 4- by 4-inch sodium iodide (thallium-activated) crystal connected to a 400-channel gamma spectrometer. Individual radionuclides are quantitated from spectrometer data by the use of a computer and a matrix technique. The 5- and 12-day beta counts are used to extrapolate gross beta concentrations to mid-collection time for reporting. Extrapolation is accomplished by computer programs and is routinely based on a $T^{-1.2}$ decay. For known

Figure 2. WERL Air Surveillance Network stations outside Nevada

Table 1. Summary of gross beta radioactivity concentrations in air, August 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Ariz:	Kingman	30	<0.1	0.2	0.4
	Phoenix	28	<.1	.1	.3
	Seligman	31	<.1	.2	.5
	Winslow	31	.1	.2	.5
Ark:	Little Rock	18	<.1	.2	.5
Calif:	Baker	27	<.1	.3	.5
	Barstow	30	<.1	.3	.5
	Bishop	30	.1	.3	.5
	Death Valley Junction	30	<.1	.3	1.0
	Furnace Creek	30	.1	.3	.5
	Indio	31	.1	.2	.4
	Lone Pine	29	<.1	.2	.5
	Needles	29	<.1	.2	.5
	Ridgecrest	30	.1	.2	.4
	Shoshone	31	.1	.2	.4
Colo:	Denver	19	<.1	.3	.5
	Durango	31	<.1	.2	.7
Idaho:	Boise	31	<.1	.3	.9
	Idaho Falls	22	.1	.3	1.0
	Preston	31	.1	.5	1.5
	Twin Falls	31	<.1	.3	.9
Iowa:	Iowa City	21	.1	.4	1.0
	Sioux City	26	<.1	.3	.8
Kans:	Dodge City	31	<.1	.1	.3
La:	Lake Charles	21	.1	.2	.6
	Monroe	17	<.1	.2	.4
	New Orleans	18	.1	.2	.7
Minn:	Minneapolis	22	.1	.3	.6
Mo:	Joplin	29	.1	.4	.8
	St. Joseph	31	.1	.4	.8
	St. Louis	31	.1	.4	.7
Nebr:	North Platte	26	<.1	.3	.9
Nev:	Alamo	29	<.1	.2	.3
	Austin	29	.1	.3	.5
	Battle Mountain	24	.1	.2	.6
	Beatty	31	.1	.3	.5
	Blue Eagle Ranch (Currant)	30	.1	.3	.5
	Blue Jay	31	<.1	.2	.3
	Caliente	30	.1	.2	.4
	Currant Ranch	31	<.1	.2	.5
	Currie	29	<.1	.3	.8
	Diablo	31	.1	.3	.5
	Duckwater	25	<.1	.2	.5
	Elko	29	<.1	.3	.6
	Ely	30	.1	.2	.5
	Eureka	31	<.1	.3	.5
	Fallini's Twin Springs Ranch	31	.1	.3	.5
	Fallon	31	.1	.3	.6
	Frenchman Station	31	<.1	.3	.8
	Geyser Maintenance Station	25	.2	.3	.6
	Goldfield	32	<.1	.2	.5
	Groom Lake	25	<.1	.2	.4
	Hiko	31	<.1	.2	.5
	Indian Springs	31	<.1	.2	.5
	Las Vegas	22	<.1	.2	.4
	Lathrop Wells	31	<.1	.3	2.2
	Lida	31	<.1	.2	.4
	Lovelock	31	<.1	.3	.8
	Lund	28	.1	.2	.6
	Mesquite	31	.1	.2	.5
	Nyala	30	<.1	.2	.5
	Pahrump	25	.1	.2	<.7
	Pioche	31	<.1	.2	.6
	Reno	21	.2	.3	.5
	Round Mountain	31	<.1	.2	.4
	Scotty's Junction	31	<.1	.3	.5
	Stone Cabin Ranch	31	<.1	.2	.4
	Sunnyside	27	<.1	.2	.4
	Tonopah	31	<.1	.3	1.0
	Tonopah Test Range	27	<.1	.2	.4
	Warm Springs Ranch	31	<.1	.2	.6
	Wells	31	<.1	.3	1.0
	Winnemucca	31	<.1	.3	.6
N. Mex:	Albuquerque	26	<.1	.2	.6
	Carlsbad	27	<.1	.2	.4
Okla:	Muskogee	31	<.1	.3	.8
Oreg:	Burns	29	<.1	.3	.6
	Medford	23	<.1	.3	.7
S. Dak:	Aberdeen	31	.1	.4	.9
	Rapid City	31	.1	.3	.8
Tex:	Abilene	29	<.1	.2	.7
	Amarillo	31	<.1	.3	.5
	Austin	11	.1	.2	.4
	Fort Worth	19	<.1	.3	.9

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, August 1971—Continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Utah:	Bryce Canyon	24	<.1	.2	.5
	Cedar City	27	<.1	.2	.6
	Delta	31	<.1	.2	.8
	Dugway	31	<.1	.3	.8
	Enterprise	30	.1	.2	.7
	Garrison	31	<.1	.2	.8
	Logan	31	.1	.3	.9
	Milford	30	<.1	.2	.7
	Monticello	28	<.1	.2	.5
	Parowan	31	<.1	.2	.7
	Provo	26	<.1	.3	.9
	Roosevelt	31	<.1	.2	.6
	Salt Lake City	30	<.1	.3	1.0
	St. George	31	<.1	.2	.5
	Wendover	31	.1	.3	.9
Wash:	Seattle	22	.1	.2	<1.4
	Spokane	18	.1	.3	.7
Wyo:	Rock Springs	31	<.1	.3	.7
	Worland	31	.2	.4	.9

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

Table 2. Summary of gross beta radioactivity concentrations in air, September 1971

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Ariz:	Kingman	30	0.1	0.3	1.1
	Phoenix	30	.1	.2	.5
	Seligman	30	<.1	.3	.5
	Winslow	30	<.1	.2	.4
Ark:	Little Rock	17	<.1	.2	.4
Calif:	Baker	26	.1	.3	.5
	Barstow	30	<.1	.2	.6
	Bishop	30	<.1	.3	.9
	Death Valley Junction	30	<.1	.3	.9
	Furnace Creek	29	.1	.3	.9
	Indio	30	.1	.2	.4
	Lone Pine	30	<.1	.3	.8
	Needles	28	.1	.3	.4
	Ridgecrest	30	<.1	.2	.4
	Shoshone	30	.1	.2	.8
Colo:	Denver	21	<.1	.2	.3
	Durango	30	<.1	.3	.8
Idaho:	Boise	30	<.1	.2	.6
	Idaho Falls	20	.1	.2	.5
	Preston	30	<.1	.2	.6
	Twin Falls	30	<.1	.2	.5
Iowa:	Iowa City	21	<.1	.2	.4
	Sioux City	24	<.1	.2	.5
Kans:	Dodge City	30	<.1	.1	.3
La:	Lake Charles	20	<.1	.1	.4
	Monroe	19	.1	.1	.4
	New Orleans	20	<.1	.1	.3
Minn:	Minneapolis	20	<.1	.2	.6
Mo:	Joplin	29	<.1	.2	.5
	St. Joseph	30	<.1	.2	.5
	St. Louis	30	<.1	.2	.4
Nebr:	North Platte	26	<.1	.2	.4
Nev:	Alamo	30	.1	.2	.7
	Austin	28	<.1	.2	.8
	Battle Mountain	29	.1	.2	.7
	Beatty	30	<.1	.3	1.0
	Blue Eagle Ranch (Currant)	29	.1	.3	.9
	Blue Jay	30	.1	.2	.8
	Caliente	30	.1	.3	.8
	Currant Ranch	30	<.1	.2	.6
	Currie	31	<.1	.3	.8
	Diablo	30	.1	.3	1.0
	Duckwater	28	<.1	.2	.7
	Elko	30	<.1	.2	.6
	Ely	29	<.1	.3	.9
	Eureka	31	.1	.3	.9
	Fallini's Twin Springs Ranch	30	.1	.3	.9
	Fallon	30	<.1	.3	.5
	Frenchman Station	30	<.1	.3	.6

See footnote at end of table.

Table 2. Summary of gross beta radioactivity concentrations in air, September 1971 —Continued

Location		Number of samples	Concentration[a] (pCi/m³)		
			Minimum	Average	Maximum
Nev:	Geyser Maintenance Station	9	.2	.4	.9
	Goldfield	30	<.1	.3	.9
	Groom Lake	28	.1	.3	.9
	Hiko	30	<.1	.3	.8
	Indian Springs	30	<.1	.3	.8
	Las Vegas	20	.2	.4	1.3
	Lathrop Wells	31	.1	.3	1.1
	Lida	30	.1	.3	.7
	Lovelock	30	<.1	.2	.6
	Lund	29	.1	.3	.9
	Mesquite	30	<.1	.3	.5
	Nyala	30	<.1	.3	.9
	Pahrump	21	.1	.2	.8
	Pioche	30	<.1	.2	.6
	Reno	27	<.1	.2	.5
	Round Mountain	29	.1	.3	.9
	Scotty's Junction	30	<.1	.3	1.0
	Stone Cabin Ranch	29	<.1	.2	.7
	Sunnyside	22	.1	.2	.7
	Tonopah	30	<.1	.3	.8
	Tonopah Test Range	20	<.1	.3	.9
	Warm Springs Ranch	30	.1	.2	.6
	Wells	30	<.1	.2	.6
	Winnemucca	31	.1	.2	.7
N. Mex:	Albuquerque	22	.1	.2	.5
	Carlsbad	29	<.1	.2	.5
Okla:	Muskogee	27	<.1	.1	.4
Oreg:	Burns	30	<.1	.2	.3
	Medford	23	<.1	.2	.5
S. Dak:	Aberdeen	30	<.1	.2	.5
	Rapid City	30	<.1	.2	.5
Tex:	Abilene	29	<.1	.2	.4
	Amarillo	30	<.1	.2	.5
	Austin	2	.1	.1	.1
	Forth Worth	21	<.1	.2	.5
Utah:	Bryce Canyon	21	.1	.2	.7
	Cedar City	30	.1	.3	.7
	Delta	29	<.1	.3	.7
	Dugway	30	<.1	.2	.7
	Enterprise	30	.1	.3	.6
	Garrison	30	.1	.3	.8
	Logan	29	<.1	.2	.6
	Milford	28	.1	.3	.8
	Monticello	26	<.1	.2	.3
	Parowan	30	<.1	.3	1.2
	Provo	29	.1	.3	.7
	Roosevelt	30	<.1	.2	.5
	Salt Lake City	30	<.1	.2	.6
	St. George	30	.1	.3	.7
	Wendover	30	<.1	.2	.6
Wash:	Seattle	21	.1	.1	.2
	Spokane	9	<.1	.2	.3
Wyo:	Rock Springs	30	<.1	.2	.6
	Worland	29	<.1	.2	.5

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1 pCi/m³.

releases of radioactivity the decay rate is determined experimentally and is used in the extrapolations.

Results

Table 1 presents the monthly average gross beta radioactivity in air particulates during August 1971; table 2 presents the data for September 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m³. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06–0.07 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m³) are reported as <0.1 pCi/m³.

From gamma spectrometry results in August, zirconium-niobium-95, ruthenium-106, and cerium-144 from worldwide fallout were

identified in varying combinations on filters collected in Colorado, Iowa, Louisiana, Minnesota, and Texas. The highest concentrations of these radionuclides, respectively, were 0.2 pCi/m^3 (Iowa City and Minneapolis), 0.4 pCi/m^3 (Denver), and 0.5 pCi/m^3 (Lake Charles). From the September results, zirconium-niobium-95 was identified on filters from California, Idaho, and Nevada. The highest concentration was 0.3 pCi/m^3 at Alamo, Duckwater, Goldfield, and Indian Springs, Nev. No radioactivity above background levels was identified on any of the charcoal cartridges collected in August or September.

Complete summaries of daily station results are distributed to EPA regional offices and State health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, January-March 1971 [1]

Office of Radiation Programs
Environmental Protection Agency

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

[1] Period during which death or surgical procedure occurred.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

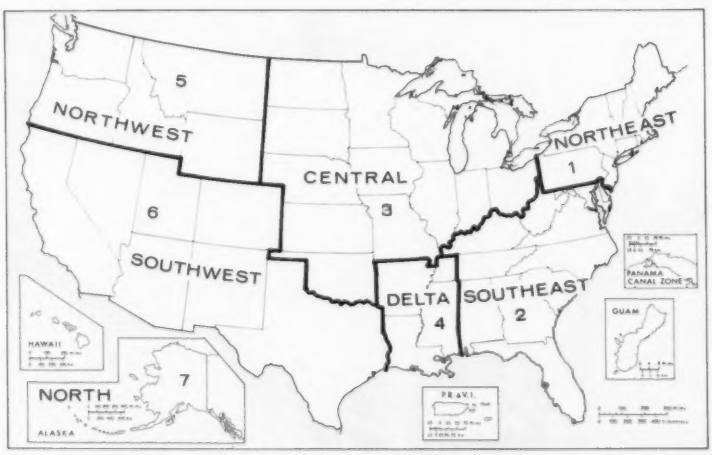

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, January–March 1971

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c,d] (pCi/kg bone)	Calcium concentration (g/kg bone)[d]	$^{90}Sr/Ca$ (pCi/g)
Northeast:						
Massachusetts	V	1	M	81.5±9.3	28.2	2.89
	V	1	F	74.6±9.1	26.3	2.84
New York	V	2	M	50.6±7.0	25.1	2.01
Massachusetts	V	3	F	34.5±7.3	35.4	.98
Pennsylvania	V, R, I	5	F	109.9±9.4	43.4	2.53
New Hampshire	V	9	M	104.9±10.6	38.1	2.75
Pennsylvania	V, R, I	10	F	31.4±5.2	27.3	1.15
New York	V	14	M	53.1±8.1	31.6	1.68
Pennsylvania	V, R, I	14	M	129.9±19.3	89.3	1.45
	V, R, F	17	M	208.3±21.3	95.5	2.18
New York	V	19	M	103.9±9.5	44.0	2.36
	V	20	M	43.4±7.3	34.4	1.26
	V	21	F	49.1±7.1	38.6	1.27
	V	21	M	37.4±6.1	28.1	1.33
Pennsylvania	V	23	M	40.7±6.5	44.9	0.91
New York	V	23	M	64.0±8.2	51.1	1.25
	V	23	M	111.4±10.5	52.3	2.13
	V	24	M	55.3±8.8	38.4	1.44
Pennsylvania	V	24	M	77.2±9.0	48.3	1.60
New York	V	25	F	73.2±9.4	54.2	1.35
Southeast:						
Maryland	V	1	M	69.1±8.4	38.6	1.79
South Carolina	V	2	M	142.8±11.5	38.8	3.69
Maryland	V	6	M	69.2±10.6	33.8	2.05
	V	7	F	52.7±8.1	26.5	1.98
	V	9	F	60.2±10.9	30.0	2.01
	V	10	M	117.8±14.8	41.9	2.81
North Carolina	V, R	11	M	63.7±10.2	32.6	1.95
Maryland	V	13	F	77.1±10.9	47.0	1.64
	V	14	M	121.2±9.9	54.8	2.21
	V	14	M	121.3±9.1	49.6	2.44
	V	15	M	52.2±7.6	40.9	1.28
	V	16	F	93.9±12.3	45.6	2.06
	V	17	F	124.3±15.0	54.0	2.30
	V	17	M	102.6±12.8	56.1	1.83
	V	17	M	69.9±9.3	43.1	1.62
	V	17	F	211.2±17.6	62.9	3.36
Tennessee	V	18	M	78.5±7.7	48.3	1.62
Virginia	V	18	M	62.3±9.3	44.5	1.40
South Carolina	V	18	M	54.4±7.7	27.5	1.97
Maryland	V	18	M	138.6±13.0	54.7	2.53
South Carolina	V	19	M	137.1±12.4	46.4	2.96
Maryland	V	19	F	104.3±8.4	25.4	4.10
Delaware	V	19	M	105.8±13.9	58.2	1.82
Virginia	V	20	M	67.9±9.8	52.8	1.29
Maryland	V	20	M	75.2±8.9	47.0	1.60
	V	21	M	84.9±12.1	55.0	1.54
	V	21	F	89.6±10.9	54.2	1.65
	V	21	M	64.2±12.1	50.6	1.27
	V	21	M	99.6±12.0	42.6	2.34
	V	22	M	62.7±7.6	37.5	1.67
	V	23	M	85.7±10.9	46.4	1.85
	V	23	M	45.4±7.3	39.9	1.14
	V	23	M	75.4±9.1	57.5	1.31
	V	23	M	76.0±10.1	56.8	1.34
	V	23	F	42.7±7.4	37.8	1.13
	V	23	M	63.4±7.6	41.3	1.53
	V	23	M	54.7±7.9	35.9	1.52
	V	23	M	46.9±8.2	43.5	1.08
	V	24	M	64.5±8.7	42.2	1.53
Tennessee	V	24	M	122.5±10.8	53.9	2.27
Maryland	V	24	M	66.2±9.1	48.5	1.37
	V	24	F	44.2±8.3	35.8	1.24
	V	24	M	56.3±8.4	43.4	1.30
	V	24	M	92.2±10.3	45.0	2.05
	V	24	M	124.7±13.3	65.8	1.90
South Carolina	V	25	F	114.7±10.9	49.4	2.32
Maryland	V	25	F	50.1±7.0	56.5	.89
	V	25	M	170.2±13.6	53.5	3.18
Central:						
Ohio	V	1	F	52.0±9.2	33.0	1.57
Wisconsin	V	1	M	104.3±12.8	41.7	2.50
	V	2	M	93.0±10.9	34.3	2.71
	V	2	F	56.9±7.6	39.2	1.45
Ohio	V	3	M	81.8±9.6	29.2	2.80
Wisconsin	V	4	F	70.6±9.1	35.1	2.01
Illinois	V	4	F	77.5±9.7	30.9	2.51
Wisconsin	V	5	F	85.1±10.3	33.0	2.58
Ohio	V	6	M	56.2±9.0	35.7	1.57
	V	7	M	65.7±9.6	42.1	1.56
	V	8	M	89.1±9.5	39.0	2.28
Michigan	V	14	M	58.9±8.3	41.8	1.41
Ohio	V	15	M	100.0±9.9	56.9	1.76
Michigan	V	16	M	147.9±12.7	66.5	2.22
Ohio	V	16	M	106.6±9.9	48.5	2.20
	V	16	M	104.7±11.5	63.1	1.66
	V	16	M	99.9±11.0	55.3	1.81
	V	17	F	100.2±12.2	55.5	1.81

See footnotes at end of table.

Table 1. Strontium-90 in human bone, January–March 1971—continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c,d] (pCi/kg bone)	Calcium concentration (g/kg bone)[d]	$^{90}Sr/Ca$ (pCi/g)
Central:						
Ohio	V	18	M	117.2±12.3	62.1	1.89
	V	18	M	95.3±11.6	54.9	1.74
	V	18	M	165.6±15.6	55.6	2.98
	V	18	M	113.8±12.2	67.2	1.69
Michigan	V	18	F	147.4±10.4	53.8	2.74
Ohio	V	19	M	107.4±11.2	58.8	1.83
	V	19	M	109.1±13.8	63.3	1.72
	V	20	M	80.3±8.9	58.5	1.37
	V	20	F	97.1±10.5	52.6	1.84
	V	20	F	82.2±9.2	57.1	1.44
	V	20	F	95.0±12.3	57.7	1.65
	V	21	F	121.9±14.8	64.4	1.89
	V	21	M	94.1±8.8	46.1	2.04
	V	22	M	72.1±8.5	59.0	1.22
	V	22	M	64.5±9.9	51.8	1.25
	V	22	M	81.8±9.9	61.2	1.34
	V	22	M	94.9±10.4	52.6	1.80
Michigan	V	23	M	79.2±8.1	48.1	1.65
Ohio	V	23	M	75.8±11.6	63.8	1.19
	V	24	F	107.9±10.0	41.8	2.58
	V	24	M	84.1±11.6	67.6	1.24
Michigan	V	25	M	88.1±10.1	49.8	1.77
Ohio	V	25	F	54.1±8.9	54.4	.99
	V	25	F	96.0±10.8	72.3	1.33
	V	25	M	72.4±9.0	66.7	1.09
Delta:						
Louisiana	R	3	F	183.4±14.6	72.0	2.55
Northwest:						
Oregon	V	18	M	55.0±9.6	63.2	.87
	V	20	M	84.6±9.6	55.3	1.53
	V	23	M	61.4±8.8	57.1	1.07
Southwest:						
California	V	17	F	60.7±8.2	53.8	1.13
Texas	V	17	M	59.4±8.2	50.0	1.19
	V	24	M	41.2±8.4	38.4	1.07

[a] Type of bone, V, vertebrae; R, rib; I, ilium; F, femur.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.
[d] Sample preparation is not uniform at the various collection sites, and these ratios are not to be taken as absolute. This should not materially affect the $^{90}Sr/Ca$ ratios.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January–March) of 1971 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of data at appropriate stages in the program (*2–6*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1970	September 1971

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY, Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

(*6*) BARATTA, E. J., E. S. FERRI, and M. A. WALL. Strontium-90 in human bones in the United States, 1962–1966. Radiol Health Data Rep 11:183–186 (April 1970).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Feed Materials Production Center and the Savannah River Plant.

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1. Feed Materials Production Center[2] January-June 1971

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project are concerned with the processing of high-grade uranium concentrates into metallic uranium. These processes include acid digestion of the concentrates, organic phase extraction of uranyl nitrate, subsequent conversion of the uranyl nitrate to uranium oxide and tetrafluoride, reduction to uranium metal, and fabrication of the metal into fuel elements. The project also includes plants for sampling of the concentrates and recovery of uranium from various residues. The final product is used in the nation's production reactors.

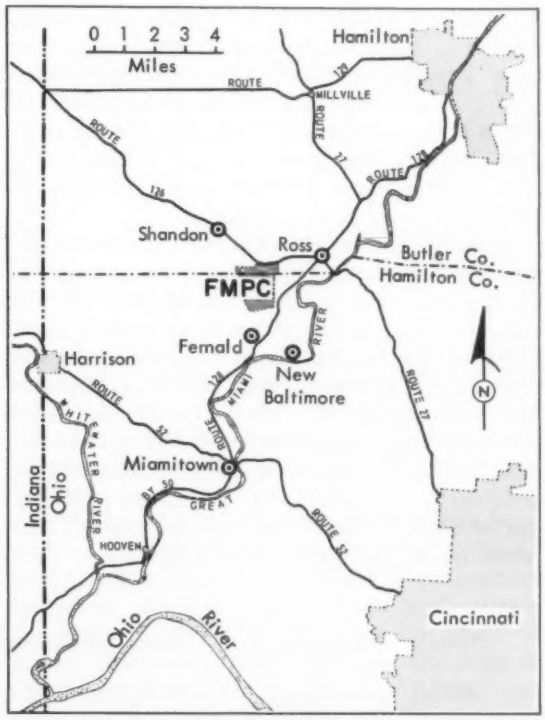

Figure 1. Area map of Feed Materials Production Center

The project also processes thorium to produce purified thorium compounds and metal. The production methods are similar to those used in producing uranium.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Feed Materials Production Center Environmental Monitoring, Semiannual Report for the First Half of 1971 (NLCO–1085)."

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. An environmental monitoring program has been established to determine the concentrations of radioactive materials in the water and air outside the project.

Air monitoring

Air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and gross alpha and gross beta radioactivity. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the project.

In previous reports, data were given for offsite air samples. Collection of these random, short-term samples was discontinued at the end of 1970 because of the questionable reliability of the results. Plans are now underway to construct six permanent sampling locations along the project boundary. Continuous samples collected at these locations will give better data regarding uranium and radioactivity in the nearby offsite air. Concentrations of uranium and alpha and beta radioactivity of airborne particulates are given in table 1.

The results of sampling indicate that the concentrations at onsite locations averaged 1.0 percent, 1.0 percent, and 0.02 percent of the AEC standards for uranium, alpha radioactivity and beta radioactivity.

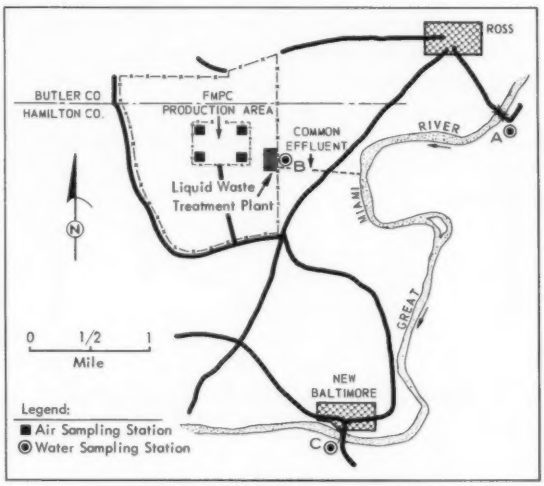

Figure 2. Air and water sampling stations Feed Materials Production Center

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process wastewater. The effluents from the plants are collected at a general sump for additional treatment and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then combined with three other types of project wastewater and discharged via a

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1971

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Alpha radioactivity[a] (pCi/m³)			Beta radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Southwest	26	0.08	<0.01	0.02	0.07	<0.001	0.02	0.43	0.04	0.19
Northwest	26	.13	<.01	.02	.14	<.001	.02	.52	.04	.20
Northeast	26	.08	<.01	.02	.08	<.001	.02	.55	.03	.19
Southeast	26	.07	<.01	.02	.06	<.001	.02	.40	.02	.18
Summary	104	.13	<.01	.02	.14	<.001	.02	.55	.02	.19

[a] AEC radiation protection standard—2 pCi/m³ (natural uranium).
[b] AEC radiation protection standard—1 nCi/m³ (thorium-234).

common effluent outfall into the Great Miami River. At location B, a Parshal-Flume-type water sampler collects samples of the combined effluent stream which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream (location A); a continuous sample is taken for a 24-hour period downstream (location C), and at least one sample is analyzed each week. All samples are analyzed for uranium, gross alpha and gross beta radioactivity, and radium-228, a daughter of thorium-232. Since radium-228 has the lowest AEC standard, control of this radionuclide and of the gross radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate that each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for January–June 1971 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	March 1971
July–December 1970	September 1971

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center, January–June 1971

Location	Number of samples	Uranium[a] (pCi/liter)			Alpha radioactivity[b] (pCi/liter)			Beta radioactivity[b] (pCi/liter)			Number of samples	Radium-228[c] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Sewer outfall[d] (location B)	181	182	<1	2	1,002	<1	8	921	<1	54	11	0.06	<0.01	0.02
Upstream from outfall (location A)	27	20	<1	4	39	<1	22	40	4	18	6	.9	<.01	.4
Downstream from outfall (location C)	27	6	<1	2	41	<1	4	40	9	18	6	.9	<.01	.4

[a] AEC standard—20 nCi/liter (natural uranium).
[b] AEC standard—3 nCi/liter (certain mixtures of alpha and beta emitters).
[c] AEC standard—30 pCi/liter (radium-228).
[d] Concentrations in the river as calculated from sewer outfall sample results.

2. Savannah River Plant[3] January-June 1971

E. I. DuPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. DuPont de Nemours and Company, occupies an area of 310 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square-mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1971" (DPSPU 71-30-16).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 3). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background radioactivity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

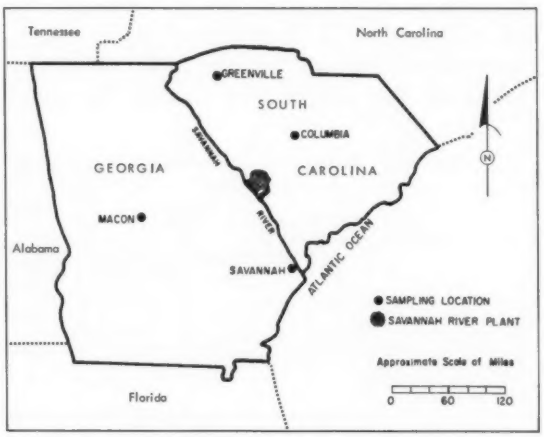

Figure 4. Distant air monitoring stations Savannah River Plant

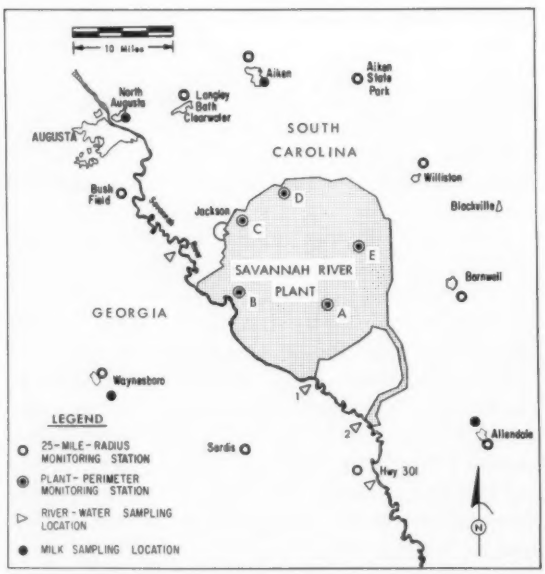

Figure 3. Environmental sampling locations Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separation areas, was obscured by fallout. The influence of nuclear tests, which resumed in September 1961, is shown in figure 5. The present low levels of atmospheric activity are attributed to the moratorium on above-ground nuclear tests, which began in 1962. The slightly increasing trend (1967 through 1970) is attributed to fallout from atmospheric testing by nations who did not agree to the moratorium. Some increases typically occur each spring as a result of the mixing of the stratospheric debris into the troposphere. The average beta concentration in air increased from 0.17 pCi/m^3 to 0.33 pCi/m^3 during the first half of 1971. Gamma-emitting radionuclides in fallout were cesium-134, –137, cerium-141, –144, ruthenium-103, –106, and zirconium-niobium-95.

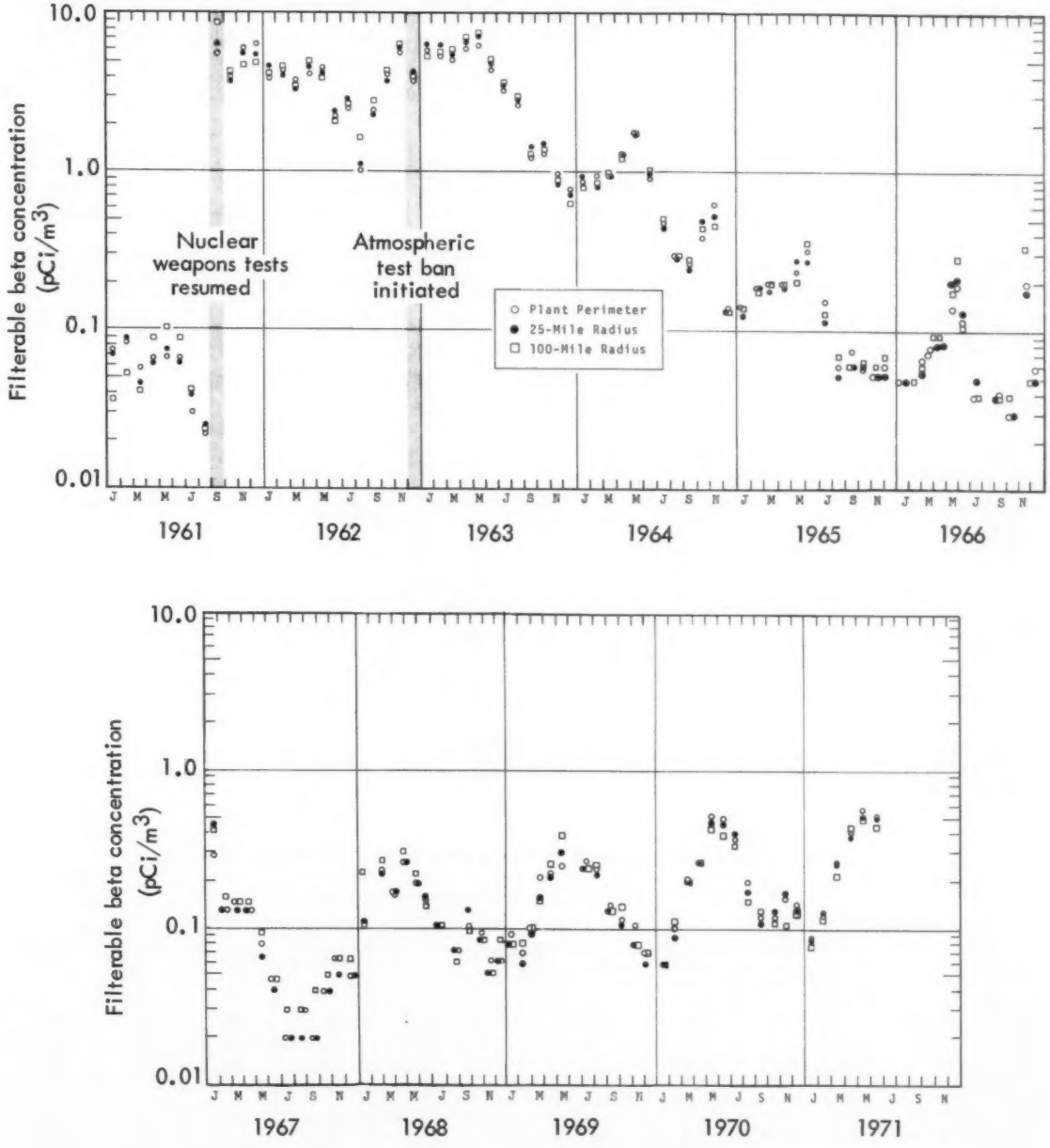

Figure 5. Influence of weapons tests

Radioactivity in air, determined from filter analyses, is shown in table 3. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. The January–June 1971 concentrations of filterable beta radioactivity (0.33 pCi/m³) and alpha radioactivity (0.9 pCi/m³) in air were 0.33 and 1.3 percent of the respective AEC standards. Tritium oxide concentrations

Table 3. Radioactivity in air, Savannah River Plant, January–June 1971

Sampling points	Alpha radioactivity[a] (fCi/m³)			Nonvolatile beta radioactivity[b] (pCi/m³)			^{131}I[c] average	Special radionuclides in composite samples (pCi/m³)					
	Maximum	Minimum	Average	Maximum	Minimum	Average		^{89}, ^{90}Sr	^{137}Cs	^{141}, ^{144}Ce	^{103}, ^{106}Ru	^{95}Zr-Nb	^{7}Be
Plant perimeter:													
A	1.3	0.5	0.8	0.70	0.10	0.35	ND						
B	2.1	.7	1.0	.69	.06	.31	ND						
C	1.6	.6	.9	.74	.09	.34	ND	0.01	0.01	0.07	0.10	0.18	0.23
D	1.3	.4	1.0	.86	.08	.41	ND						
E	1.0	.5	.8	.68	.08	.34	ND						
Average			.9			.35	ND						
25-mile-radius:													
Aiken Airport	1.7	.4	.8	.67	.06	.31	ND						
Aiken State Park	1.6	.4	.8	.75	.08	.30	ND						
Allendale	1.5	.5	1.1	.67	.09	.32	ND						
Barnwell	1.8	.5	1.3	.66	.08	.32	ND						
Bush Field	1.3	.7	1.0	.76	.08	.33	ND	.01	.01	.07	.09	.17	.24
Langley	1.6	.7	1.4	.86	.09	.36	ND						
Sardis	1.2	.4	.8	.68	.06	.31	ND						
Waynesboro	1.4	.7	1.0	.75	.09	.35	ND						
Williston	1.5	.4	1.0	.71	.08	.32	ND						
Highway 301	1.3	ND	1.0	.73	.09	.32	ND						
Average			1.0			.32	ND						
Distant air-monitoring:													
S.C.:													
Columbia	2.4	ND	1.1	.93	.06	.34							
Greenville	1.2	.5	.8	.65	.06	.34							
Ga.:													
Macon	1.8	ND	.8	.66	.04	.28		.01	.02	.08	.09	.19	.26
Savannah	1.8	ND	.7	.73	.03	.32							
Average			.8			.32							

[a] AEC radiation protection standard–70 fCi/m³, sensitivity of analysis—0.3 fCi/m³.
[b] AEC radiation protection standard–100 pCi/m³, sensitivity of analysis—0.006 pCi/m³.
[c] AEC radiation protection standard—100 pCi/m³, sensitivity of analysis—0.02 pCi/m³.
ND, nondetectable.

Table 4. Total fallout deposited, Savannah River Plant, January–June 1971

Sampling points	Radionuclide concentration (nCi/m²)								
	Alpha[a]	Strontium–89	Strontium–90	Cesium–137	Cerium–141,-144	Zirconium–niobium–95	Ruthenium–103,-106	Iodine–131	Beryllium–7[b]
Plant perimeter:									
A	3.5	1.3	0.8	1.8	10.2	10.8	6.1	ND	40.2
B	4.3	1.0	.7	1.7	13.9	13.4	6.8	ND	48.4
C	4.3	2.0	.8	2.1	15.3	14.7	7.1	ND	54.3
D	3.3	1.8	.7	1.6	13.0	10.1	6.5	0.5	39.3
E	3.1	1.8	.8	1.9	13.4	14.9	6.1	ND	47.7
Average	3.7	1.6	.8	1.8	13.2	12.8	6.5	.1	46.0
25-mile radius:									
Aiken Airport	2.9	1.4	.9	2.1	14.9	20.6	6.5	ND	48.2
Aiken State Park	6.6	1.3	.8	1.8	10.3	13.7	5.6	ND	39.3
Allendale	3.7	1.5	.7	1.6	11.5	15.2	5.8	ND	40.5
Barnwell	4.5	1.1	.5	1.2	7.8	10.7	5.1	ND	27.3
Bush Field	4.0	.6	.8	1.9	14.8	16.9	6.0	ND	51.4
Langley	4.9	1.6	1.0	2.4	13.4	17.4	7.1	ND	53.7
Sardis	5.6	1.1	.6	1.7	9.6	15.5	5.9	ND	33.3
Waynesboro	3.1	1.6	.8	2.0	11.7	16.2	6.3	ND	41.7
Williston	3.0	1.5	.7	1.8	10.3	13.4	5.5	ND	40.7
Highway 301	2.1	.5	.7	1.2	7.2	7.8	5.8	ND	25.1
Average	4.0	1.2	.8	1.8	11.2	14.7	6.0	ND	40.1

[a] Multiply by 10^{-2}.
[b] A naturally occuring radionuclide.
ND, less than the sensitivity of analysis.

in air, at the plant perimeter and at the 25-mile-radius stations, did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during January–June 1971 averaged 37 nCi/m² at the plant perimeter locations and 36 nCi/m² at 25-mile-radius locations; comparable values for the last half of 1970 were 17 and 15 nCi/m² (excluding naturally occurring beryllium-7). Deposition at each sampling location is presented in table 4.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 6). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. The reactors are cooled and moderated by heavy water which, in turn, is cooled by river water in heat exchangers. This arrangement prevents irradiation of the river water, so that radioactivity is discharged into the river water only on the rare occasions when small quantities of moderator are lost by heat exchanger leaks.

The irradiated fuel (canned to prevent leaching of radionuclides) discharged from a reactor is stored in a large, water-filled basin that is

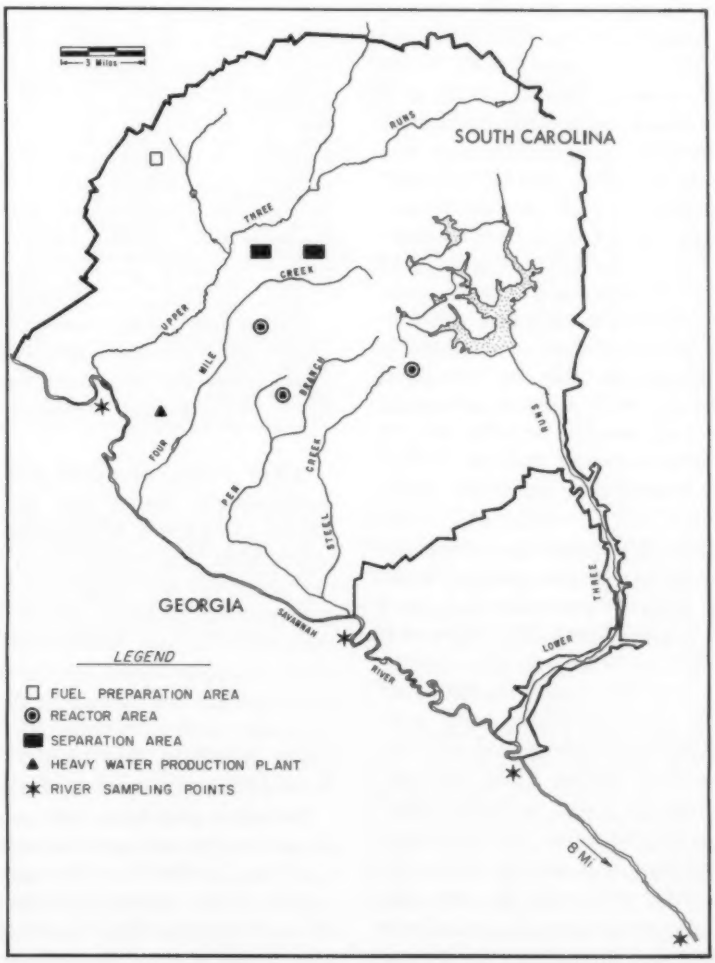

Figure 6. SRP production and effluent streams

purged to maintain clarity and to control water temperature. Newly discharged fuel is placed into an isolated section of the basin that is equipped with a water circulating system. Portable filters and deionizers are provided to remove a large percentage of the radionuclides, and a heat exchanger is used to control basin water temperature. Tritium from the irradiation of the D_2O moderator accounts for the largest quantity of radioactivity released by the reactors to the effluent streams. However, the contribution to the Savannah River results in concentrations less than 1 percent of the AEC standard.

The Beaufort-Jasper Water Authority operates a treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 1.9 nCi/liter (0.06 percent of the AEC standard) during the January–June period. The annual radiation exposure of an individual in this population due to the consumption of 1.2 liters per day of water containing the very low concentration of tritium is 0.17 mrem (this exposure may be compared with 20 mrem per year from natural potassium found in the body of all persons or with the 170 mrem per year specified by the Federal Radiation Council as the annual dose guide for members of the public).

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.1 pCi/liter) and beta radioactivity (5 pCi/liter) were essentially the same as those observed before plant startup. The higher than average alpha activity found in some drinking water supplies (for example, 8.2 pCi/liter at Jackson) was due to naturally-occurring radioactivity, primarily thorium-228 and its short-lived daughter products. Analyses of public drinking water for tritium by a new, more sensitive method detected measurable, but very low levels of tritium in the water supplies derived from surface water (maximum of 750 pCi/liter). Concentrations of tritium in water supplies using only deep wells were less than the sensitivity of the analysis (400 pCi/liter). Previously, tritium was below the former limit of detection (1,000 pCi/liter) in all drinking water samples. Radioactivity in public water supplies data is presented in table 5.

Table 5. Radioactivity in public water supplies, SRP April 1971

Sampling points	Source of water	Alpha radioactivity[a] (pCi/liter)	Nonvolatile beta radioactivity[b] (pCi/liter)	Tritium[c] (pCi/liter)
Aiken	Stream, well	2.7	6	750
Allendale	Deep well	ND	ND	ND
Augusta	River	.3	ND	650
Barnwell	Deep well	.5	ND	ND
Bath	Lake	1.8	6	ND
Blackville	Deep well	.5	ND	ND
Clearwater	Lake	.7	ND	650
Jackson	Deep well	8.2	18	ND
Langley	Stream	3.6	7	430
New Ellenton	Deep well	1.3	ND	ND
North Augusta	River	.4	ND	500
Sardis	Deep well	ND	4	ND
Waynesboro	Stream	ND	8	580
Williston	Deep well	2.2	4	ND
Average		1.6	6	

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
[c] AEC radiation protection standard—3 μCi/liter; sensitivity of analysis—400 pCi/liter.
ND—less than the sensitivity of analysis.

River water, analyzed weekly, was sampled continuously above and below the plant as shown in figure 6. Concentrations of alpha and nonvolatile beta radioactivity in river water for the past year are presented in table 6. The upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests; the downstream measurements reflect the operation of the SRP reactors. Average concentrations of specific radionuclides found in river water during January–June 1971 appear in table 7.

Tritium, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents.

Table 6. Radioactivity in Savannah River water, January–June 1971

Sampling points	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	January–June 1971			July–December 1970	January–June 1971			July–December 1970
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.4	ND	ND	ND	12	ND	4	4
8 miles downstream from Lower Three Runs Creek	.6	ND	ND	ND	13	ND	6	7

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, less than the sensitivity of analysis.

Table 7. Average concentration of radionuclides in Savannah River water January–June 1971

Radioactivity	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	Percent AEC standard at Highway 301
Tritium	600	680	5,800	0.19
Sulphur-35	5.0	ND	ND	< .01
Chromium-51	4.3	ND	ND	< .001
Manganese-54	.4	ND	ND	< .0004
Cobalt-60	1.4	ND	ND	< .005
Zinc-65	1.1	ND	ND	< .001
Strontium-89	.3	ND	.7	.02
Strontium-90	.01	.6	.9	.30
Zirconium-niobium-95	.5	ND	ND	< .001
Ruthenium-103,-106	3.2	ND	ND	< .03
Iodine-131	.2	ND	ND	< .07
Cesium-134,-137	.6	ND	.2	.001
Barium-lanthanum-140	1.6	ND	ND	< .01
Cerium-141,-144	2.5	ND	ND	< .02
Neptunium-239	2.2	ND	ND	< .002

ND, nondetectable, less than sensitivity of analysis.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavywater moderator in the reactors. The concentration of tritium in river water averaged 0.19 percent of the AEC standard.

Fish in Savannah River

Fish traps were maintained upstream, adjacent to, and downstream from the Savannah River Plant effluents, throughout this period. Individual whole fish were analyzed by gamma spectroscopy for cesium-137 and other gamma-emitting radionuclides. Bone from each specimen was composited monthly for strontium-89 and strontium-90 analysis. Concentrations of specific radionuclides in fish are summarized in table 8. The radioactivity in bone and flesh indicates some minor contribution by SRP. The concentrations, however, are of minor significance when referenced against intake guides defined by the AEC radiation protection standard.

Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route

Table 8. Radioactivity in Savannah River fish, January–June 1971

Location	Number		Type of sample	Concentration (pCi/g wet weight)					
				Cesium–137				Strontium–89,–90	
				Bream[a]		Catfish[b]		Bream and catfish	
	Bream	Catfish		Maximum	Average	Maximum	Average	Maximum	Average
Above plant boundary	18	75	Bone	NA	NA	NA	NA	23	12
			Flesh	25	3.2	15	3.6	NA	NA
Adjacent to plant	14	27	Bone	NA	NA	NA	NA	21	13
			Flesh	18	6.3	21	6.6	NA	NA
Below plant at Highway 301	89	22	Bone	NA	NA	NA	NA	9	8
			Flesh	20	4.5	11	4.9	NA	NA

[a] Shellcracker, bluegill, and redbreast (Lepomis).
[b] Predominantly yellow cat (Ictalurus).
NA, no analysis.

(these are not designated on figure 6). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and at the 25-mile radius locations, as compared to 0.1 pCi/g at both locations during the last half of 1970; gamma-ray emitters averaged 38.4 and 32.4 pCi/g, respectively, as compared to 11.1 and 9.9 pCi/g for the last half of 1970. Radioactivity in grass samples is presented in table 9.

Table 9. Radioactivity in vegetation, January–June 1971

Radionuclides	Sensitivity of analysis (pCi/g dry weight)	Concentration (pCi/g dry weight)			
		Plant perimeter (7 locations)		25-mile radius (7 locations)	
		Maximum	Average	Maximum	Average
Alpha emitters	0.10	1.1	0.2	0.7	0.2
Cesium-137	.3	3.8	1.6	1.1	.8
Cesium-141,–144	1.0	27.5	13.0	14.1	10.4
Ruthenium-103,–106	1.4	4.4	3.1	5.0	2.8
Beryllium-7[a]	3.0	35.5	16.3	23.1	14.6
Zirconium-niobium-95	.5	11.0	4.4	5.2	3.8

[a] A natural radionuclide.

Milk

Milk was sampled at four dairies within a 25-mile radius of the Savannah River Plant (figure 3). Samples were collected biweekly and analyzed for tritium and radioiodine. Analyses were made quarterly for strontium-90 and monthly for cesium-137. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from the analyses of milk for radioactivity during January–June 1971 are shown in table 10.

Average concentrations of the radionuclides in milk were 9 pCi/liter of strontium-90 (3.0 percent of the AEC standard) and 18 pCi/liter of cesium-137 (0.09 percent of the AEC standard) compared to 12 pCi/liter of strontium-90 and 40 pCi/liter of cesium-137 during the last half of 1970. Iodine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the Pasteurized Milk Network for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1.3 nCi/liter) was 0.04 percent of the AEC standard for water.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1971 data (table 11) are characteristic of measurements observed at individual stations for the past several years.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation

Table 10. Radioactivity in milk from local dairies, Savannah River Plant January–June 1971

Sampling points	Concentration (pCi/liter)							
	Tritium[a]			Strontium-90[b]		Cesium-137[c]		
	Maximum	Minimum	Average	March	June	Maximum	Minimum	Average
Aiken	960	ND	460	7	7	20	10	16
Barnwell	5,500	1,000	2,800	NS	11	26	16	21
North Augusta	4,700	350	1,500	NS	17	30	8	20
Waynesboro	1,900	390	1,000	8	NS	20	9	15
Major distributors[d]	1,400	200	730	8	8	22	10	17

[a] Sensitivity of analysis—200 pCi/liter; AEC standard—3,000 nCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter; AEC standard—300 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter; AEC standard—20 nCi/liter.
[d] Milk produced in local dairies but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Table 11. Environmental gamma radiation Savannah River Plant, January–June 1971

Sampling points	Gamma radiation (mR/24 h)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.25	0.11	0.20
B	.27	.08	.16
C	.20	.13	.16
D	.19	.12	.16
E	.20	.11	.18
Average			.18
25-mile-radius:			
Aiken Airport	.18	.08	.15
Aiken State Park	.15	.12	.14
Allendale	.19	.11	.15
Barnwell	.20	.16	.18
Bush Field	.25	.12	.19
Langley	.23	.14	.17
Sardis	.21	.14	.17
Waynesboro	.21	.08	.15
Williston	.20	.14	.17
Highway 301	.25	.12	.20
Average			.17

or was obscured by fallout from offsite sources. Beta radioactivity in air, which showed no relationship with plant operations and was due to global fallout, was slightly higher than that observed for the same period of 1970 and was a two-fold increase over the previous 6-month period. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed 0.3 percent of the AEC radiation protection standard.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	July 1971
July–December 1970	August 1971

Reported Nuclear Detonations, February 1972

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations reported by the U.S. Atomic Energy Commission for February 1972 for the United States.

The U.S. Atomic Energy Commission announced that the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals originated at approximately midnight, EST, February 9, 1972, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the intermediate yield range of 20 to 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish them for their files.

RADIOACTIVE WASTE DISCHARGES TO THE ENVIRONMENT FROM NUCLEAR POWER FACILITIES. *Joe E. Logsdon, Radiation Data and Reports, Vol. 13, March 1972*, pp. 117–129.

Data relating to discharges of radioactive liquid and gaseous waste have been compiled for 12 selected operating nuclear power facilities. These data are presented and compared to discharge limits and quantity of electric power produced. In most instances, concentration of radioactivity in waste discharge limits have been maintained at a few percent of the Atomic Energy Commission's licensed discharge limits. Exceptions are mostly associated with either an unusually high percentage of leaky fuel elements or with liquid discharge limits which are artificially low because liquid wastes, in some cases, are not analyzed for radionuclide content.

Comparison of power produced to liquid and gaseous waste discharges showed that boiling water reactors discharge relatively large quantities of gaseous waste and pressurized water reactors discharge relatively high quantities of tritium in liquid waste. No obvious trend is discernible concerning the quantity of radioactive waste discharged as a function of power generation.

KEYWORDS: Air, nuclear power facilities, nuclear reactors, radioactive waste discharges, United States, water.

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